FARM MECHANICS

FIELD - OLSON - NYLIN

FARM MECHANICS

A GUIDE-BOOK FOR
STUDENTS AND FARMERS

A farm shop.

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A GUIDE-BOOK FOR
STUDENTS AND FARMERS

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PREFACE

The present tendency in school management is to organize instruction so as to meet more adequately the individual needs of the students. In agriculture this tendency finds expression in the attempt to meet these needs of the boys in terms of the demands of individual farms. Not only is the mechanical work that a farmer is called upon to do determined by the individual farm, but much of it should also be done on the farm.

A survey of the literature treating of farm shop instruction leads one to the conclusion that there is too great a tendency on the part of teachers of agriculture to think of "farm shop" work as dealing mainly with those activities which can conveniently be carried on in a "shop" under teacher controlled conditions. In contrast to this point of view, the authors believe that most of the so-called "farm shop" work should be done in its natural setting, which is the home farm. A difficulty which presents itself in this connection is that the teacher does not have time to visit each farm to give the instruction and help required in order to perform the various activities.

It is the purpose of this book to furnish the farmer and the student with a guide which will make it possible for them to do on the farm the ordinary repair and construction work that should be done. By following the carefully prepared step-by-step directions for the representative farm repair and construction jobs, the farmer or the student can do much of the needed mechanical work of the farm independent of the guidance of a teacher. At the same time the book provides directions and information of a very practical kind which will aid students in their work with tools and farm machinery when done at the school. In this way it will serve as a handbook for the farm, a textbook for the student, and a reference book for the novice in farm work.

The book should be helpful in vitalizing the farm practice work engaged in by students enrolled for instruction in vocational agriculture, and should be a valuable aid to the teacher in correlating the mechanical work with other forms of farm practice activities. The jobs selected are those which are fundamental to practically all farm repair and construction work.

As the book is designed to serve as a guide for boys of high school age or for mature persons, the authors have assumed that the probable user has already acquired sufficient skill in the necessary fundamental tool operations to perform any of the jobs or groups of jobs listed under the various chapters. No attempt has been made to arrange the material in any sequence which makes it necessary for the user to begin with any particular chapter. If one wishes guidance in any proposed farm mechanics activity, he should turn to the Table of Contents to find where the group of activities is treated, or to the Index to find the place where the specific job or the specific desired information is presented. The various groups of jobs are prefaced by the shop information thought essential to a better understanding of the directions for performing the jobs listed. In the form presented. it is hoped that the content may prove helpful as a guide to better care and use of farm mechanical equipment.

A. M. Field.
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V. E. Nylin.

FOREWORD

Farm mechanics of every kind is now recognized as one of the most important, if not the most important part of productive agriculture. Any farmer who undertakes to operate a farm without tools and without machines is doomed to failure from the start. Any farmer who does not learn how to care for and handle his mechanical equipment properly will never get very far in the farming game, no matter what he tries to produce. Consequently, training in farm mechanics and books giving help in this work have become necessary and vital contributions to agriculture and agricultural education.

Few people understand how much the modern farmer relies on tools and labor-saving devices. No less an authority than the United States Department of Agriculture has estimated that an agricultural worker of to-day is equal in the amount of work he does to seventy tillers of the soil at the time that Christ was born. This difference is due to the fact that in the first century of the Christian era, only a few appliances were known, and these of the rudest and crudest kind, while to-day science and invention have made available a great wealth of wonder-working tools and machines. Someone has aptly said that a tool is only the lengthened arm of a man. The farmer of our own times can, if he will, use an arm seventy times as long as that of a Galilean peasant. All he needs to do is to get the right kind of farm equipment, learn how to keep it in repair, and use it intelligently.

This shift from hand-work and from crude machines to constantly improving farming devices is constantly going on. "Seventy-five years ago, the average agricultural worker could care for but twelve acres of crops; now, considering the United States as a whole, he can attend to at least thirty-four acres. In some states where large power units are common, the average crop per man is more than 100 acres, while on many individual farms it will run as high as 300 acres or more." * Since the Civil War, the productive arm of our farmers has been lengthened from three to twenty-five times because of the increased use of improved tools and power-driven machinery.

"The total amount of power used annually on farms in the United States amounts to approximately 16,000,000,000 horse power hours while the cost under 1924 conditions, averages about 19 cents per horse power hour or close to $3,000,000,000 for the year . . . Power and labor represent on the average approximately 60 per cent of the total cost of producing farm products . . . The primary horse power available for use in agriculture is greater than that available for either mining or manufacturing and is second only to that used by the railroads . . . Implements and machinery on the farms of this country represent an investment equivalent to 27 per cent of that invested in farm buildings in the United States."

Much has been said concerning the necessity that the farmer should know his soil and the kind of crop that can best be produced on it; that he should understand how to conserve the fertility of his land; that he should know how to keep simple farm accounts; that he should understand how to market his products to the best advantage; and that he should be informed concerning all the special problems involved in the particular farming enterprises in which he engages. All these things and many more are essential to a prosperous agriculture. None of them are, however, any more vital to his success and few of them as vital, as his ability to use tools and labor-saving machinery.

Tools must be purchased, used, and kept in good condition. Buildings must be erected and he must build them with his own tools. Power machinery must take the place of slow hand processes. He must know how to make ordinary repairs on this equipment, keep it "tuned up" for use, and operate it. All this simply means that the successful farmer of this and succeeding generations must have a doing ability with farm tools and farm machinery. Not a theoretical ability is demanded, but a doing ability; not information about how to do things, but skill, according to farm standards, in the use of in-

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* Report of Committee on the Preparation of Farm Shop Teachers," Agricultural Education Section, American Vocational Association, Louisville, Kentucky, December 2-4, 1926.

formation for getting things done with mechanical appliances. It is from this standpoint that this book has been written.

Several attempts have been made to define what school men call the objective or aim of training in farm mechanics. This book sets up as this aim or objective helping farmers and farmers' boys to acquire a greater ability to do the mechanical work of the farm.

Any text which undertakes to help in this service must have certain features or characteristics. Such a book should give aid both to the farmer already engaged in the practice of agriculture and to his son who is just beginning to deal in a responsible way with farming. Whatever helps the boy improves agriculture for the future. Whatever helps the man on his home acres improves agriculture now. Even a hasty glance at the book will show that it tries to serve both.

Not a few, but all of the mechanical activities of the farm need to be covered in the text. This is one of the outstanding points of strength of this publication. Both farm shop work and farm machinery work are included. There is need for a farm shop and tools and for help in doing the kind of work that is done in farm shops. At the same time, the book recognizes that much and perhaps most mechanical work on the farm is not done in the farm shop. Buildings must be erected outside of the shop, for example. Machinery must be set up, prepared and cared for, and operated at other points. Not hand tools alone must be used, but farm machines of various kinds. Not all the work is confined to the farm side of the problem. Much needs to be done in the farm home, and this too is provided for in the book. A wide variety of mechanical activities needs to be covered.

A glance at the table of contents will show that this text covers more mechanical activities than any other book on farm shop work and farm mechanics yet published. Ten years ago a complete book on the subject of farm mechanics was supposed to include, roughly speaking, only such things as wood, metal, and rope, and possibly harness repair and concrete work. This book covers not only these subjects, but in addition all such subjects as painting, bricks and bricklaying, glazing, pipe fitting, babbitting and bearing scraping, gas engine mechanics, farm machinery, farm radio sets, storage batteries, lighting, heating, water and rural sanitation.

Most of the books on farm mechanics previously published have given a great deal of their attention, in fact almost all of their attention, to training boys in school. The problems that have been set up have been problems that could be worked out in a school workshop. This book boldly takes the position that most of the training in farm work will, on its practice side, have to be carried on at the farm. The business of the teacher is to give help at the school-house with the aid of the text which boys can employ for project work in farm mechanics on the home farm. Consequently, the emphasis is laid, not on exercise work in the use of tools, but on real serious work in mechanics at the farm. It is assumed that the teacher at the school-house where the book is used as a text will give instruction in the use of tools. What the book provides is instruction with regard to the application of these tools in actual mechanical problems on the farm.

One great advantage gained by this is the complete divorce which takes place between the old idea of manual training exercises in agricultural high schools and the new idea of doing ability in the performance of mechanical work on the farm.

Following the general practice which has come into the field of vocational education of giving instruction through job instruction sheets, the information given the farmer or the student is embodied in the form of jobs to be done. If preliminary explanations are necessary, they are offered, and then real jobs to be done on the farm in a real way follow. Running all through these job instruction sheets are suggestions as to how to proceed in the performance of the job. This is also a new feature of books on farm mechanics.

The standard of performance is a farmer's standard. The farmer does work to meet farm needs, not city needs. His work is to be measured by farm standards and not by the standards of any skilled mechanic in the city. The very fact that he has to have some knowledge of so many different lines would make any high degree of skill impossible, even if it were necessary. What the book does is to provide in an understanding and sympathetic way just the help that the farmer needs in the purchase and use, the care and repair, and the operation and conservation of farm equipment.

The value of visual education has been fully recognized by the authors. Illustrations of tools, machines, layouts, and processes save a ton of talk or of writing and are many times as efficient in giving the reader a clear understanding of what is being taught. No other text in farm mechanics has offered such a wealth of diagrams and graphs and tables and photographs. The reader has only to turn to the copious list of illustrations to see how the book has been strengthened in this way for every use.

The book has been written by three men who have spent a great deal of their lives in dealing with these particular problems. They bring to the writing a wide knowledge of farming and of secondary education in agriculture. They have spent several years in the preparation of this book and they have checked it up from every angle in order that it may meet real needs and be accurate in the help which it offers. Under these circumstances, the book should serve the needs both of the farmer who wants a book of information and of reference for the various mechanical problems he has to face, and of the teacher and the student in the agricultural school where the effort is being made to give through farm mechanics a greater doing ability to the boys who are to be the farmers of to-morrow.

C. A. Prosser.

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FARM MECHANICS

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CHAPTER I

CONSTRUCTION AND REPAIR OF THE SMALLER FARM BUILDINGS

LUMBER

Lumber for building purposes is commonly classified as hardwood and softwood.

The hardwood trees usually have broad leaves. The softwood trees have needle-like leaves, which they do not shed. For this reason they are called evergreens.

The softwoods are used in common frame constructions and the hardwoods are used largely for interior finish. Some hardwoods are used in special-purpose construction, such as sleepers placed in concrete, and in places where exposure to decay occurs.

Trees vary in size, quality of wood, and freedom from blemishes and disease. In order to standardize lumber on the market, standard grades are worked out for the different kinds of woods and lumber.

When lumber is cut at the mill, the logs are sawed as they come out of the water. Some shrinkage in width and thickness occurs in drying after sawing, which accounts for somewhat smaller sizes when lumber is purchased from retail lumber yards. Also, when the lumber is dressed—that is, planed smooth—further reduction in size results.

The usual run of commercial size and actual size of common lumber follows:

TABLE I.

Dimension of commercial lumber		*Actual size*
1" x 6"	Common	¾" x 6 "
1" x 6"	Ship lap	¾" x 5¾"
1" x 6"	Siding	¾" x 5½"
1" x 8"	Common	¾" x 8 "
1" x 10"	Common	¾" x 10 "
2" x 4"	Common	1⅝" x 3⅝"
2" x 6"	Common	1⅝" x 5⅝"
2" x 8"	Common	1⅝" x 7½"
2" x 10"	Common	1⅝" x 9½"

In order to overcome the effect of this reduction in the size of framing lumber, the dimensions of a building are taken to the outside of the studs, and to the centers of the inside partitions. Studs are also placed sixteen inches on center to overcome the difference in dimensions, for an error of three-eighths inch multiplied by several times would throw the studs out of place.

JOB I

ESTIMATE OF LUMBER REQUIRED FOR A BUILDING

Procedure.

1. *Lumber* is figured by the board-foot as the unit, a board-foot being a square foot one inch thick.

When lumber is less than one inch thick, it is figured as one inch thick.

The length in feet multiplied by the width in feet multiplied by the thickness in inches, the product being divided by twelve, will give the number of board-feet.

A simpler and faster way is to multiply the thickness and width in inches, divide the product by twelve and multiply the result by the length in feet. This will give the number of board-feet.

2. *Studdings* usually are two by fours. The common lengths are, eight, ten, twelve, fourteen and sixteen feet. These are also used for rafters. The length of rafter to purchase is discussed under the use of the steel square.

3. *Ship lap* is cut with a joint, as shown in Figure 1. It is usually purchased six inches in width. Due to the joint, an actual face covering of about five and one-fourth inches results. If the building is small, there may be very little loss from matching, but it is usually wise to figure about a 10 per cent loss in matching. To overcome this loss and the loss in width due to the joint, add one-fifth, or 20 per cent, to the actual number of square feet to be covered by the building.

4. *Common flooring* may be purchased in a number of widths. Six-inch flooring, however, is the most common, and the same rule as for ship lap will apply in estimating the amount to purchase, as it is tongued and grooved, as shown in Figure 2.

5. *Beveled siding* usually comes in four, five or six inch widths. The amount of actual face width of the lumber will depend upon the amount the siding is lapped. See Figure 3. Thus a four-inch

siding with three and one-fourth inches exposed will require about one-fourth the amount of siding added to the estimate of the actual area to be covered. In cases where the siding is lapped an inch, the amount added to the actual estimate in square feet would be one-third.

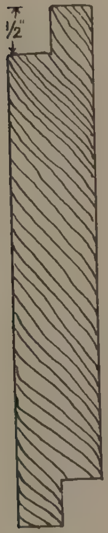


FIG. 1
Ship lap.

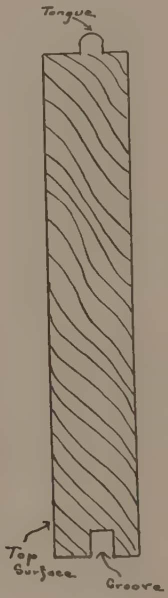


FIG. 2
Common flooring.

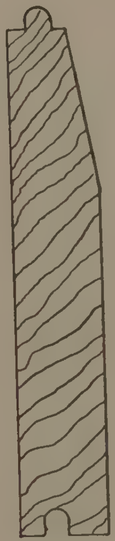


FIG. 3
Straight bevel siding.

6. *Shingles* are handled by the bunch. They are sixteen inches long and five-sixteenths inch thick at the butt, and vary in width from two and one-half to fourteen inches. The average width is figured at four inches. They are usually estimated at about 250 to the bunch. One thousand shingles are usually figured to cover 100 square feet when exposed four inches to the weather.

7. *Lath* vary in dimensions.

The size of common lath is one and one-half inches wide, one-fourth inch thick, and four feet long. This length allows proper nailing to studdings spaced either twelve or sixteen inches on centers.

The spacing of lath for ordinary lime mortar should be about three-eighths inch.

Wood lath are sold by the bundle, with 100 lath to the bundle.

8. Many patented *wall-boards* are now on the market. To estimate the amount required, find the actual amount of square feet of surface to be covered.

ROOF CONSTRUCTION

The laying-out and cutting of rafters presents the most difficult problem in the construction of the smaller common farm buildings.

With the use of the framing square, the problem becomes comparatively simple. In order to identify the parts of a roof referred to, the following explanations are given:

1. *Rise.* The rise is the distance of the upper end of the rafter above the lower end. See Figure 4.

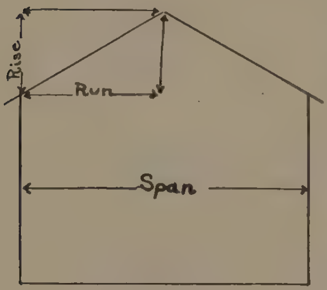


FIG. 4
Rise, run, and span used in roof construction.

2. *Span.* The span is the distance across the building. See Figure 4. The measure is taken from the outside edges of the plates. Plates are shown in Figure 8.

3. *Pitch.* The pitch of the roof means its slant or slope. See Figure 5. This is the usual term for the proportion of rise to span. Thus a roof having an eighteen-foot span and a six-foot rise would be a one-third span because the rise is one-third of the span.

4. *Run.* The run is usually considered to be one-half the span. In some broken gable-roofs, as in Figure 7, it is better to think of the run as the horizontal distance covered by one rafter.

JOB 2

LAYING OUT THE RAFTERS

Material and equipment.

Framing square; pencil; rafter.

Procedure.

1. *Shed roof.*

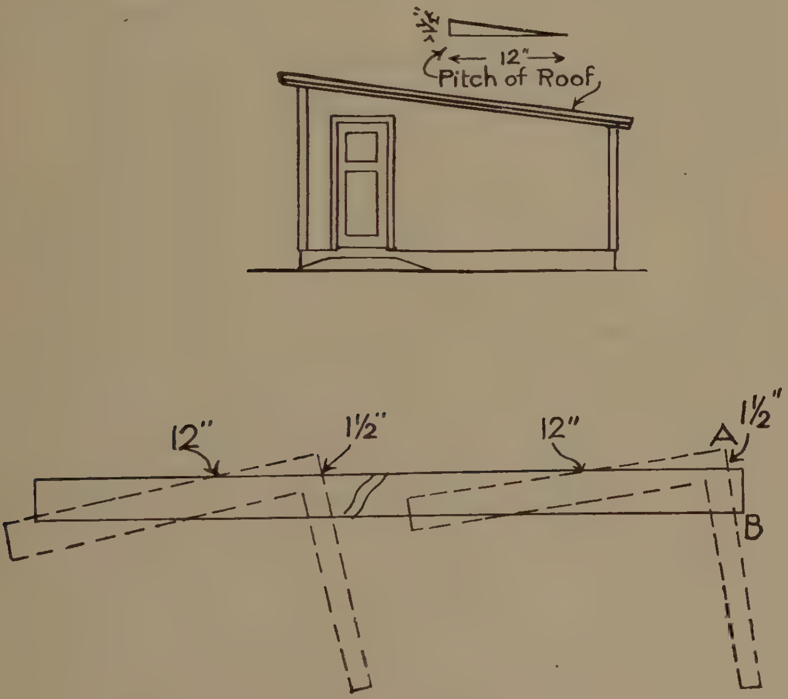


FIG. 5

Pitch and method of laying out the rafters of a shed roof.

a. In a shed roof, the span and run are the same. Thus a building with a shed roof, as in Figure 5, has a pitch of one and one-half inches to each twelve inches of span.

To find the length of rafters required, set the framing square as diagramed in Figure 5, with the one and one-half inch mark on the tongue at the edge of the rafter, and the twelve-inch mark of the blade on the same edge. If the run is sixteen feet, measure sixteen of these units of one and one-half inch rise to each twelve-inch run, and the required length of the rafter results.

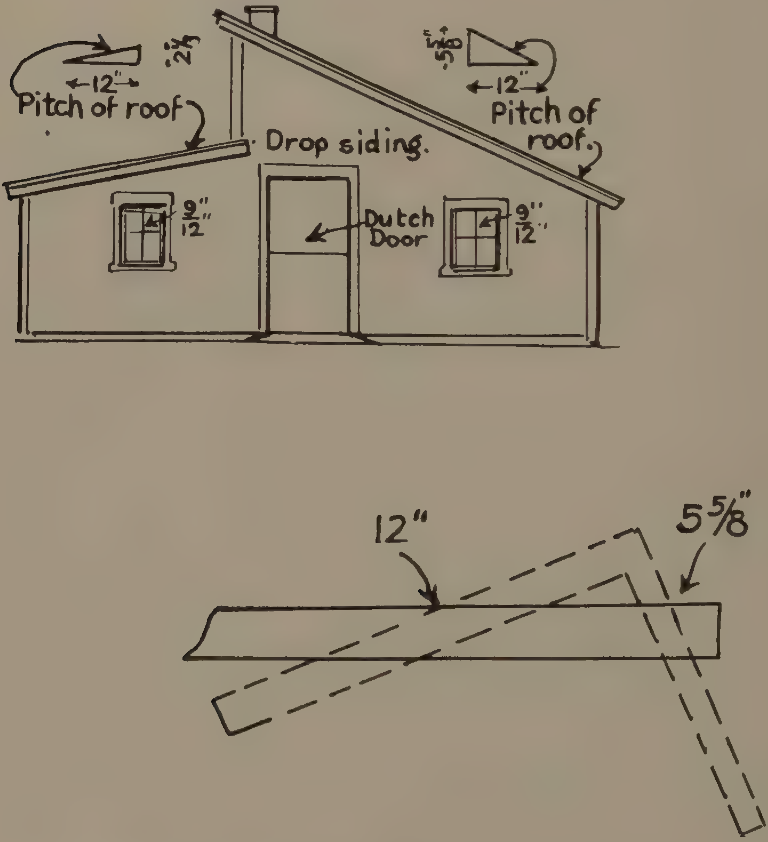


FIG. 6
Method of laying out the rafters of a half-monitor roof.

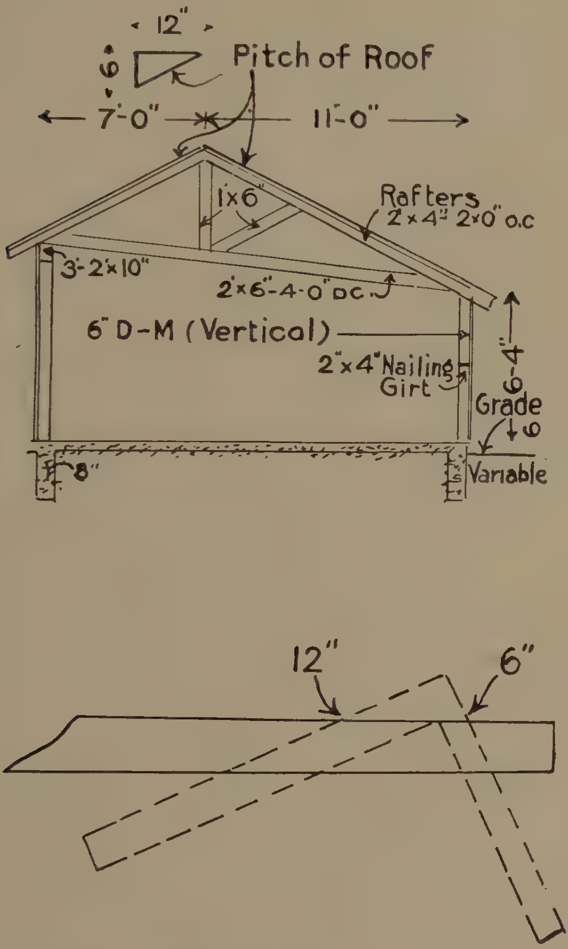


FIG. 7

Method of laying out the rafters of a broken gable-roof.

When the roof is to extend over the side of the building, the required amount should be added to the length of the rafter to provide for the "overhang."

b. Rafter cutting: The rule for finding the cut of the rafters is to place the square upon the rafter as in the diagram, Figure 5, so that a portion of one arm of the square represents the rise (one and one-half inches in this case) and a portion of the other arm the run. Draw a line on the rafter along the tongue of the square from the one and one-half inch mark (AB, Figure 5). This gives the correct angle for sawing the rafter.

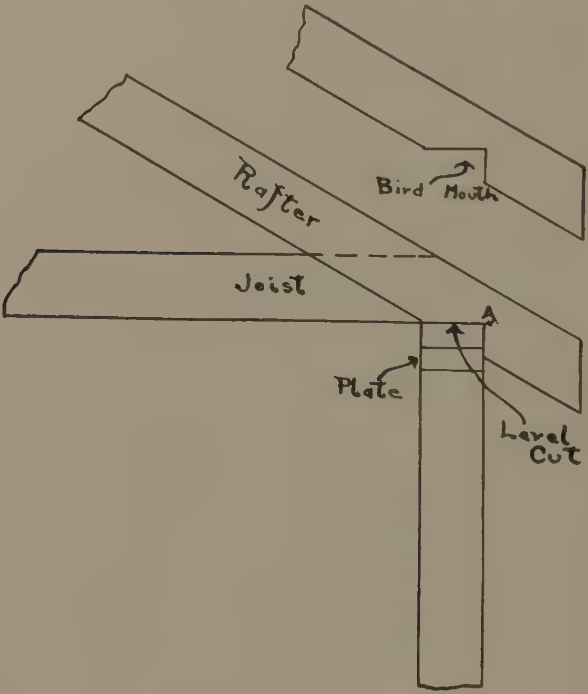


FIG. 8
The bird-mouth joint in roof construction.

2. *The half-monitor roof.* The half-monitor roof differs from the shed roof in that two different lengths of rafters and two different pitches are used on the same building. See Figure 6.

The method of laying out the rafters is similar to that used on the shed roof except that different pitches are used. Figure 6 presents a diagram of a square in position in laying out the rafter length and the angle of the rafters for the part of the roof that has a rise of five and five-eighths inches. In laying out the other side, two and one-third inches would be substituted for five and five-eighths inches.

3. *Broken gable-roof.* The broken gable-roof presents a somewhat more difficult problem in the laying out and cutting of the rafters.

Figure 7 shows the pitch of the roof to be six inches for each twelve inches of run.

In a broken gable-roof, the run and span are not alike. In Figure 7, the run is seven feet and eleven feet respectively for the two parts of the gable. In this case, two sets of rafters must be cut. For one side, the measuring unit must be placed on the rafter seven times, and for the other side, eleven times, to get the correct length for the rafters.

4. *Cutting the bird-mouth joint.* To make the rafter fit solidly onto the plate, it is necessary to notch the rafter. This is commonly called the "bird-mouth joint." The angle is marked off with the framing square.

The angle cut must be similar to the angle cut in the rafter. The "bird mouth" will be cut half the width of the rafter. The level cut will be four inches long to allow the rafter to rest on the plate. See Figure 8. This part of the rafter is known as the *heel* or *foot* of the rafter.

When a bird mouth is cut it is necessary to use the middle line of the 2x4 when finding the length of the rafter. This will allow for the added length necessary in the rafter which is about two inches with a two-by-four and about three inches with a two-by-six.

JOB 3

BRACING RAFTERS IN ROOF CONSTRUCTION

Procedure.

The braces used in the roofs of smaller buildings are usually odd pieces put in with very little thought as to the effectiveness of the bracing.

Figure 9 shows an improper method of bracing. The braces tie the rafter and joists together, but any weight on the roof brings the weight of the entire load on the joists. The weight would tend to cause the rafters and joists to settle out of their proper position.

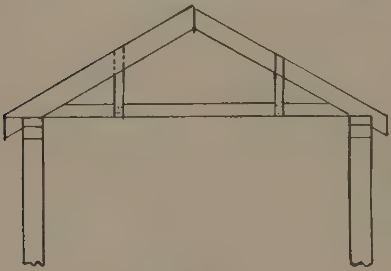


FIG. 9

Improper method of bracing a roof.

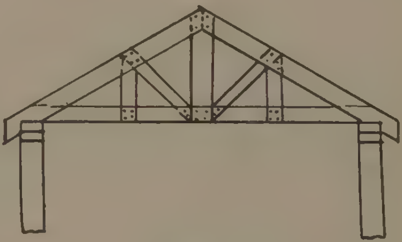


FIG. 10

Proper brace construction for a roof.

When a broken roof is used, as in Figure 10, the single center tie piece and strut brace make a rigid triangular frame which distributes the roof load on to the main walls of the building.

Where the building is wide, it may be necessary to add the extra perpendicular tie pieces shown in Figure 10. The whole framework is made rigid and distributes the weight of the roof not on the joists alone, but also on the walls of the building. Bracing every other rafter and joist is usually sufficient for common farm buildings.

THE STEEL SQUARE

The steel square is one of the most common tools. The square is an L-shaped piece of steel, and, as the name indicates, it forms a right angle or 90° angle, which is commonly spoken of as a "square."

The *face* of the steel square is the side upon which the manufacturer's name is stamped. The reverse side is the *back*.

The square in most common use consists of a "blade" 24″ x 2″ and a "tongue" 16″ x 1½″.

The edges of the face of the square have graduations in inches. These are marked off into one-half inch, one-fourth inch and one-eighth inch divisions.

The *octagon table* is along the middle of the face of the tongue. This table is used in laying off eight-sided figures.

Along the middle of the face of the tongue the graduations are numbered from left to right, while the graduations on the edges are numbered from right to left. This provides for reading directly from either end of the blade.

On the center of the back of the tongue is the *brace measure*. The use of the brace measure is explained in Job 5.

The divisions on the outer edge of the back side of the blade are graduated in twelfths of an inch instead of the usual sixteenths.

The scale of hundredths of an inch is found in the corner of the back side.

JOB 4

FINDING BOARD-MEASURE BY MEANS OF A STEEL SQUARE

General information.

The board-measure may be used in determination of the number of board-feet contained in a piece of lumber.

Procedure.

1. Find the length of the board in feet.
2. Find the width of the board in inches.

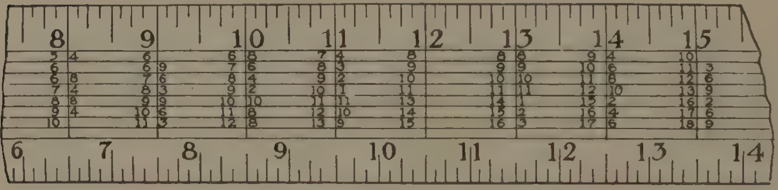


FIG. 11

Board measure on a steel square.

3. The base or starting point for lumber measurement is the column of widths found under the figure 12 on the blade. The figure 12 in the graduation marks on the outside edge represents a one-inch board twelve inches wide. The smaller figures under 12, 8-9-10-11-13-14-15, represent the length. Thus a board twelve inches wide and eleven feet long would contain eleven board-feet. See Figure 11.

4. For a board ten feet long and ten inches in width, find the number 10 in the column under 12. Since the board is ten inches wide, follow the space to the column underneath the 10 column. The number 8 4/12 is found to be the number of board-feet in the piece of lumber.

5. The board-measure of a piece of lumber 1″ x 6″ x 6′ would be found as follows:

a. The number 6 is not found under column 12.

b. Since a six-inch board would be one-half of a board twelve inches in width, use the twelve-inch width.

c. A board twelve inches wide and six feet long is found to contain six board-feet. Therefore a six-inch board would contain three board-feet.

6. In similar manner:

a. A 1″ x 3″ x 12′ piece of lumber contains three board-feet.

b. A 2″ x 4″ x 10′ piece of lumber contains six and eight-twelfths board-feet. Find the board-feet in a board 1″ x 4″ x 10′ and multiply by 2.

c. A 10″ x 10″ x 12′ piece of lumber contains 100 board-feet. Find board-feet in a board 1″ x 10″ x 12′ and multiply by 10, since the piece of lumber is ten inches thick.

JOB 5

THE USE OF THE BRACE MEASURE ON A STEEL SQUARE

Material and equipment.

Steel square.

Procedure.

1. Measure the distance AB on the post in Figure 12.
2. Measure the distance CD on the beam in Figure 12.

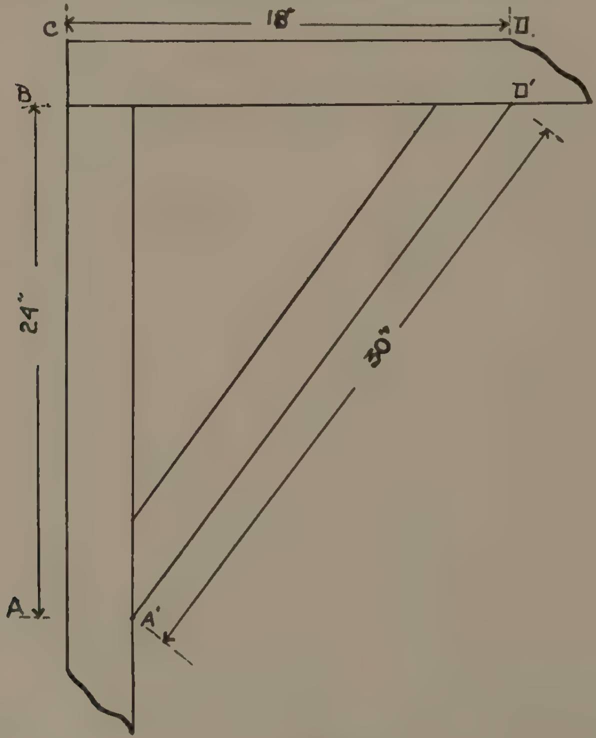


FIG. 12

Diagram for finding the length of a brace.

3. Look on the back of the tongue of the square to find the length of the brace. The 18-24 combination gives thirty inches as the length of the brace A′D′. See Figure 13.

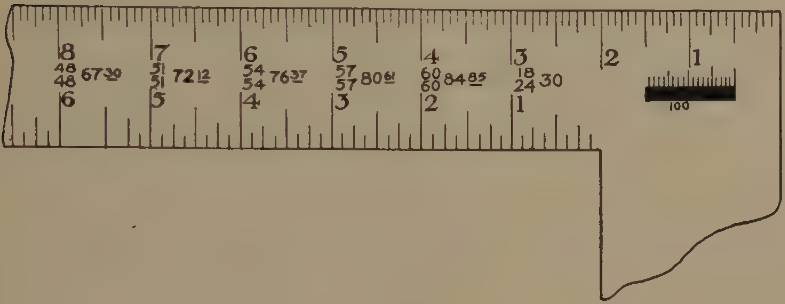


FIG. 13
Brace measure on a steel square.

4. To cut the brace the correct length, thirty inches should be marked out on the board.

5. Since the square is only twelve inches long on the tongue, it is necessary to use the figure 9 on the tongue and the figure 12 on the blade to get the proper angle cut. See Figure 14.

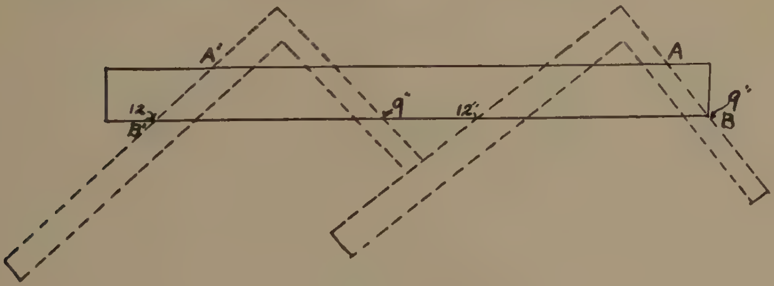


FIG. 14
Proper angle to cut the brace diagramed in Fig. 12.

6. Lay the square on the board as indicated in the diagram (Figure 14).

7. The line A′B′ indicates the correct angle for the lower cut, and the line AB, the correct angle for the cut along the beam.

8. The brace measure begins on the left end of the tongue. The figures $\genfrac{}{}{0pt}{}{24}{24}$ represent the lengths of the post and the beam, and the figures 33^{95} represent the length of the brace. Then the figures increase by threes, from 24 to 27, from 30 to 33, and so on up to 60. Almost any combination of a 45° brace can be found with the brace measure.

9. When angle braces are to be cut at other than 45° angles, the following method may be employed:

Measure the length of the post and beam as before, and proceed as for finding the angle to be cut in laying out rafters as in Job 2.

JOB 6

HANGING THE DOOR

Material and equipment.

Hammer; screw-driver; bit and brace: nails; bolts or screws for hinges; hinges or track and rollers.

Procedure.

1. *Construction of the door.* So many poorly constructed doors are put on buildings that it is seldom realized that doors should not sag out of shape or break loose from their fastenings except under some strain or accident.

The door is made to fit the opening and is securely braced to hold its form.

For the common small door shown in the diagram, Figure 15, one-inch dressed and matched lumber is most commonly used. The horizontal braces at points A and B keep the boards from separating.

a. Bracing the door. The problem of bracing the door to keep it in place presents little difficulty when it is clearly understood where the strain comes.

It is readily understood that a door hanging by two hinges has only two fastenings to keep it in place. The strain on the top fastening A is caused by the weight of the door pulling away from its fastenings.

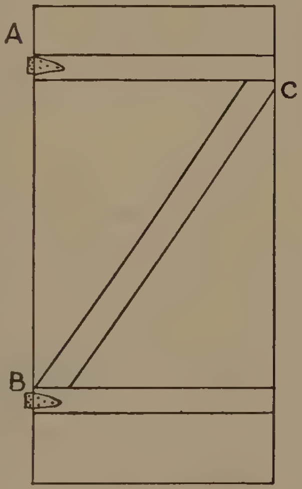


FIG. 15
Proper brace for a door.

The strain on the bottom fastening B is due to the fact that the weight of the door pushes against the hinge.

The lower hinge fastening, therefore, holds the door away from the casing, while the upper hinge fastening holds the door to the casing.

The brace for the door should therefore be placed from the lower fastening B up to the outer edge of the door at C. Such a brace will hold the door in position and prevent sagging.

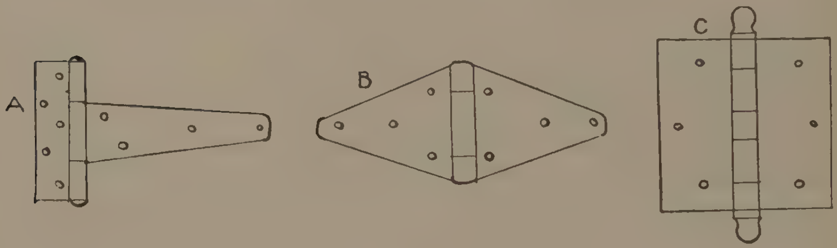


FIG. 16
A. Tee hinge. B. Strap hinge. C. Butt hinge.

2. *Selection of hinges.* The selection of hinges is determined by the kind of door and the surface available on which to fasten the hinges.

The *butt hinge,* C, Figure 16, is found on house doors, and on doors which may have to be removed quickly. A removable pin through the joint of the hinge makes the removal of the door possible by taking out the pin.

The *tee hinge* finds its place on doors where only one thickness of siding is used and the only solid place to fasten the hinge is the framework of the opening for the door. See A, Figure 16.

The *strap hinge* is used where the fastening surface available is large, and, because of the large bearing surface, this hinge is used for heavy doors. See B, Figure 16.

When the door is heavy and is to be in constant service, it is better to hang it on a *track and rollers.* This form of hanging is more expensive but eliminates the swinging of the door in the wind and prevents the frame from becoming broken. The hangers hold the weight of the door equally and the strain is only down pull, so that, if carefully put on, the door cannot sag or break loose from the fastenings.

JOB 7

PURCHASING NAILS FOR FARM BUILDINGS

Procedure.

1. *Nails.* For most of the ordinary work about the farm, the common nail will suffice. In purchasing, the various sizes are indicated as 4d (fourpenny), 5d, 16d, 20d, and so on. Some of

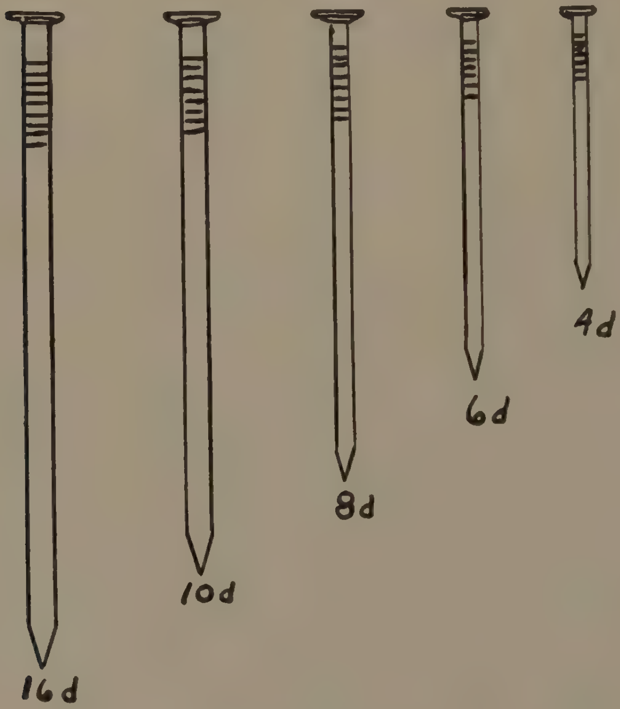


FIG. 17
Common nails.

the sizes of the common nails are shown in Figure 17. The figure shows the actual sizes of the nails.

2. *Kind and number of nails to purchase.* The question arises in building as to how many nails are needed. The practices of contractors may be used as a guide. The following suggestions may be useful in determining the kind and number.

a. Splicing lumber two inches thick: Sixteen-penny common nails will hold. These nails are three and one-half inches long and about fifty to the pound.

b. Studdings: Tenpenny common nails are large enough. If the lumber tends to split, it may be better to purchase box nails which are the same length but smaller in diameter. See

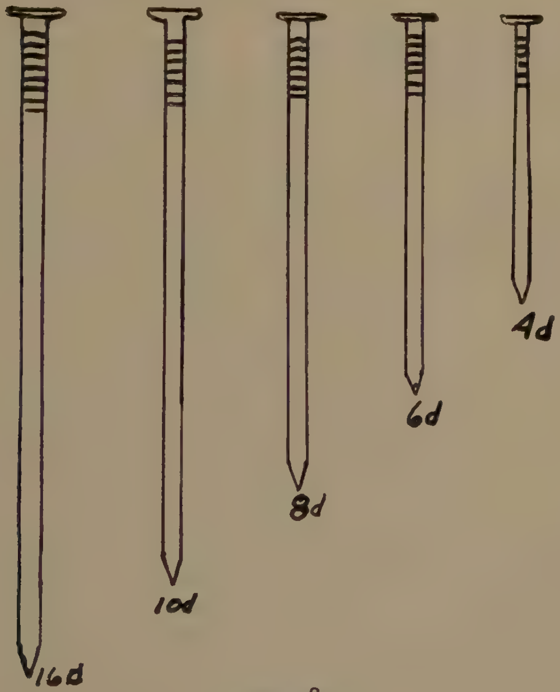


FIG. 18
Box nails.

Figure 18. Tenpenny common nails are three inches long and about seventy-five to the pound.

In estimating the amount to purchase, figure about fifteen pounds of nails for every thousand board-feet of lumber.

Box nails may be estimated at approximately one-third more in number per pound than common nails, and average about 100 nails per pound.

c. Ship lap or flooring: Eightpenny common or eightpenny box nails will be proper to use for ship lap, beveled siding, or common flooring. The nails are two and one-half inches long and the common nails average about 100 to the pound, while the box nails average about 140 nails per pound.

d. *Lap siding* may crack or split, so it is better to use a sixpenny box nail than the common nails. Sixpenny nails are two inches long and the box nails average about 225 to the pound.

JOB 8

THE USE OF THE HAND AX

Material and equipment.

Hand ax.

General information.

Many jobs that necessitate hewing wood are to be found on the farm. The hand ax finds a ready use where posts are to be squared for corner posts or gate-posts, where bulges in posts throw the wire of the fence out of line, and where poles must be hewed for use as wagon tongues and other parts of farm implements.

The hand ax may also be used in cutting stakes for braces in concrete forms and for pointing stakes and posts.

The hand ax, unlike the regular ax, has a chisel edge. This means that the back of the ax blade is straight and the front is beveled to a sharp edge. The ax is made for use in right-handed hewing.

If a left-handed ax is desired, the handle may be taken out and replaced in the ax head from the opposite direction, as in Figure 19.

Procedure.

1. In hewing, check the post along the portion to be hewed, as shown in Figure 20. This is done to prevent splitting of the post when the final cutting is done.

2. After checking the post, begin to hew out the check cuts, as in Figure 21.

3. Final trimming will smooth the cut and make the job complete. See Figure 22.

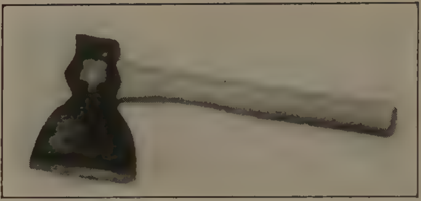


FIG. 19
Left-handed ax.

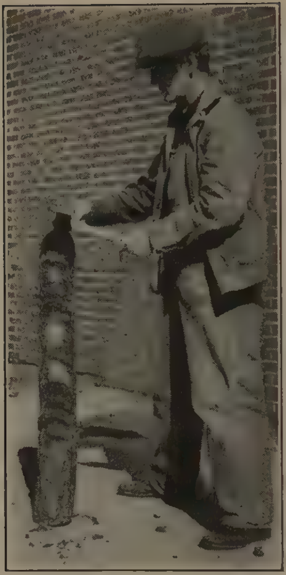


FIG. 20
Checking the post.

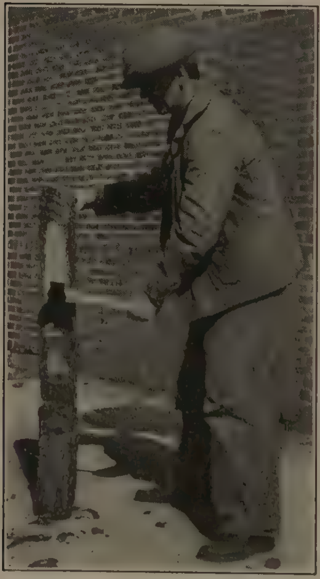


FIG. 21
Hewing the check cuts.

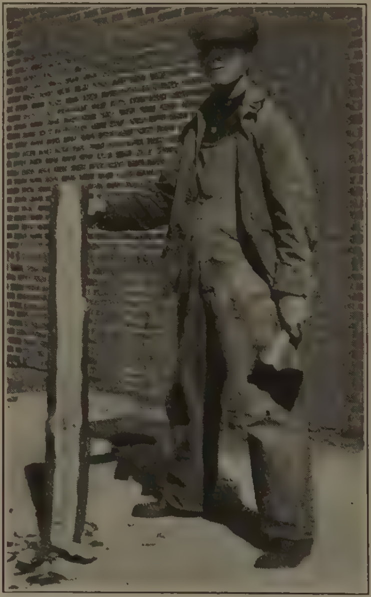


FIG. 22
Final trimming makes the post smooth.

The following tools are suggested for farm woodwork:

Framing square
Bevel square
Hand rip-saw
Cross-cut hand-saw
¼″ socket primer chisel
½″ socket primer chisel
¾″ socket primer chisel
Wood mallet (home-made)
Hand ax
Claw hammer
Brace with bits: ¼″, 5/16″, ⅜″, ½″, ¾″, and one extension bit ¾″-1″
8″ winged dividers
Compass saw
14″ jack-plane
Level
Oilstone (combination coarse and fine grit)
Drawing-knife
Spoke-shave
Wrecking bar
Screw-driver
Wood rasp
Putty knife
6″ regular-taper triangular file
6″ slim-taper triangular file

JOB 9

CONSTRUCTION OF FENCES

Material and equipment.

Wire stretcher; wire; posts; staple puller; pliers; wire cutters and splicers. See Figure 23.

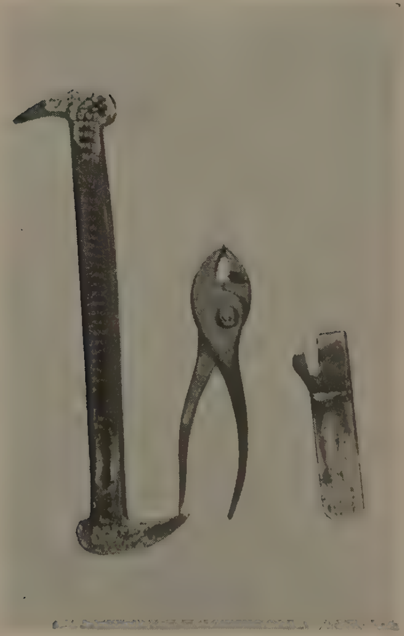


FIG. 23

Tools for fencing: Staple puller, combination pliers, splicer. (Courtesy University of Minnesota.)

Procedure.

1. *Selection of kind of fence to use.* Where only cattle are to be enclosed, barbed wire makes the cheapest fence. See Figure 24. Where horses, cattle, sheep and hogs are to be pastured, some form of woven-wire fence is the most practical.

For pasturing horses, a fence without a barbed wire on top is not practical because the horse will reach over and break it down. A fence constructed as in Figure 25, with a barbed wire above the woven wire, is a good one.

Sometimes a low woven-wire fence is used with two barbed wires on top, as in Figure 25. This type of fence is used where sheep or hogs are pastured with cattle or horses.

Where swine are pastured permanently, and where a medium to light weight of woven wire is used, it is found to be practical to run a barbed wire along the inside of the posts about an inch above the ground, to prevent the hogs from rooting the woven wire. A heavy woven wire will withstand the rooting and will turn any kind of hog, where a lighter weight would give if it were not for the barbed wire.

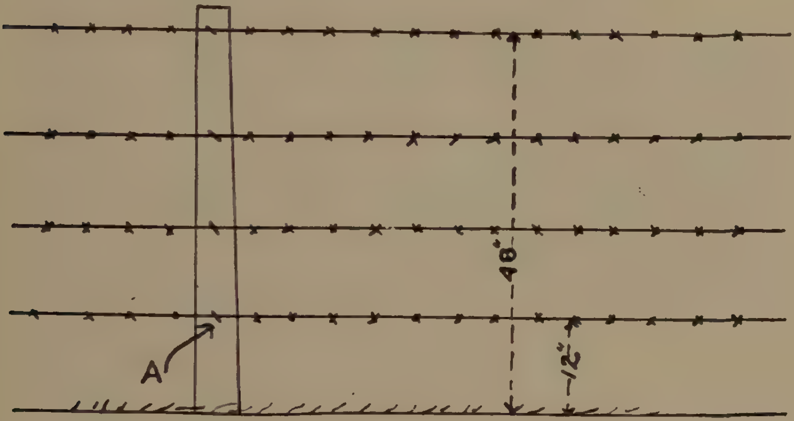


FIG. 24

Barbed-wire fence. A. Correct angle for driving staples.

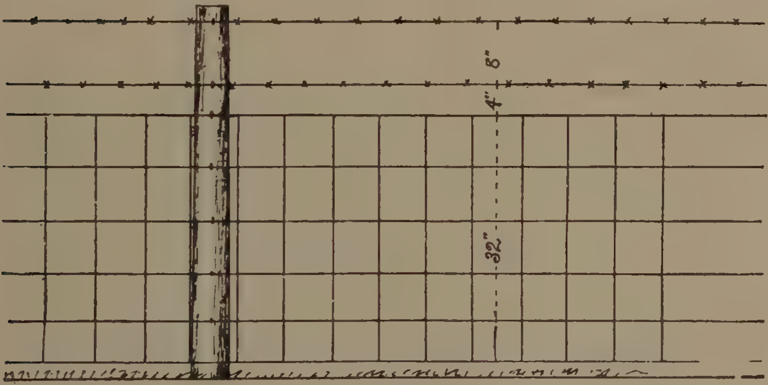


FIG. 25

A good fence that will hold cattle, horses, sheep, or swine. (Courtesy University of Minnesota.)

2. *Selecting the posts.* It would be poor economy to use high-grade wire and poor posts which would wear out in a short time.

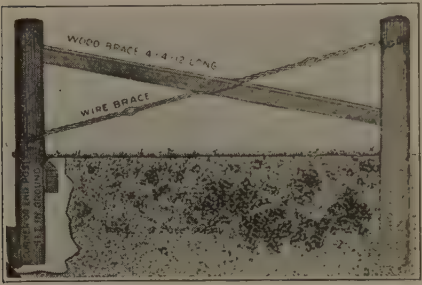


FIG. 26

Bracing the corner post. (Courtesy University of Minnesota.)

A well-made concrete post is permanent and will outlast the wire.

A treated cedar post five or six inches in diameter will also last as long as the wire.

Cheaper posts made from tamarack, jack-pine, or willow may last from eight to twelve years.

3. *Setting the posts.* The care taken in setting the corner posts practically determines the quality of the fence.

The corner posts should be at least eight inches in diameter and set about three and one-half or four feet in the ground.

A method of anchoring and bracing a corner post is shown in Figure 26. The brace should not be too long, because it will tend to buckle under the strain of the fence. The wire for the brace should be of several strands to make it strong enough to withstand the twisting and resulting pull.

In filling a hole after the post is set, thoroughly tamp each shovelful of dirt. This will set the post solidly.

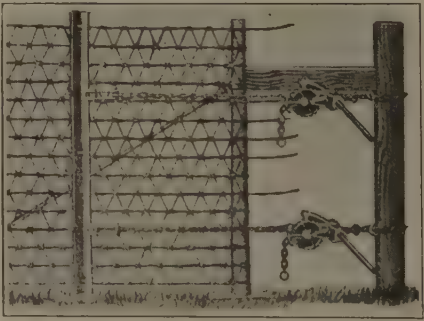


FIG. 27

Position of the stretcher in use with woven-wire fencing. (Courtesy University of Minnesota.)

4. *Stretching the wire.* When the stretcher is attached to the wire, it is necessary that the clamps be put on perpendicularly in order that the stretch will be equal at top and bottom. See Figure 27.

In using woven wire, about forty rods is the limit that can be stretched at a time. If the ground is level about 80 rods may be stretched by using a tractor.

In attaching the wire to the corner post, cut the second lateral wire from the top about two feet back of the post. Wrap this wire around the post and fasten it. Now cut the fourth wire and attach it in a similar manner. Continue until the bottom wire is reached. Then begin at the top and cut and attach the remaining wires. In this way all the slack is eliminated when the clamps are removed.

If the fence runs over a hill, it may be better to cut the fencing at the top of the hill and begin again, so as to get the top wires and bottom wires of the fence stretched evenly.

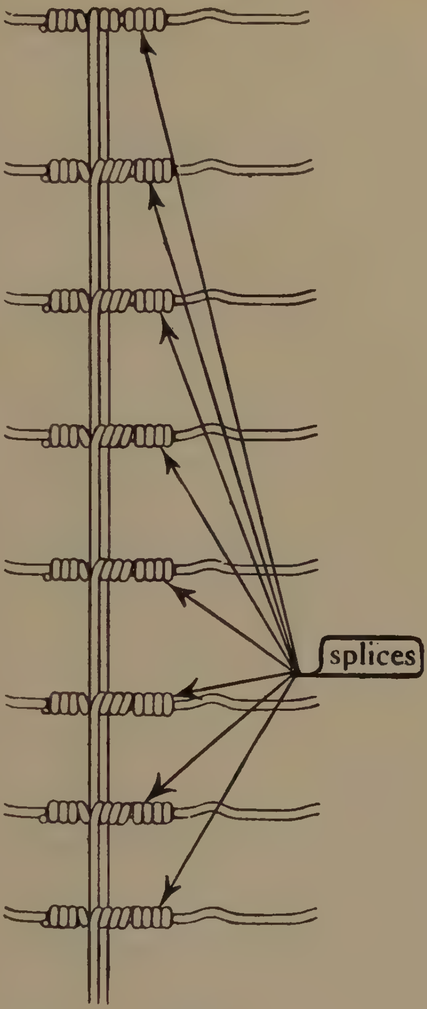


FIG. 28

Splicing the woven wire. (Courtesy University of Minnesota.)

When it is necessary to splice a woven wire, Figure 28 shows a good method. The objection to making a splice by forming two loops is that it breaks the galvanizing on the wire and makes a place for rust to begin to weaken the wire.

If the fence is a temporary one and the wire is to be taken down and rolled up again, as is often the case in hogging down corn, a convenient splice may be made as in Figure 29.

5. *Stapling.* For permanent fences, one and one-half inch staples are stronger than the one-inch size. These should not be driven at right angles to the wire, but rather at an angle of 45°. When driven at this angle, the two points of the staple do not tend to split the grain of the wood, as they do when driven at right angles to the wire. See Figure 24.

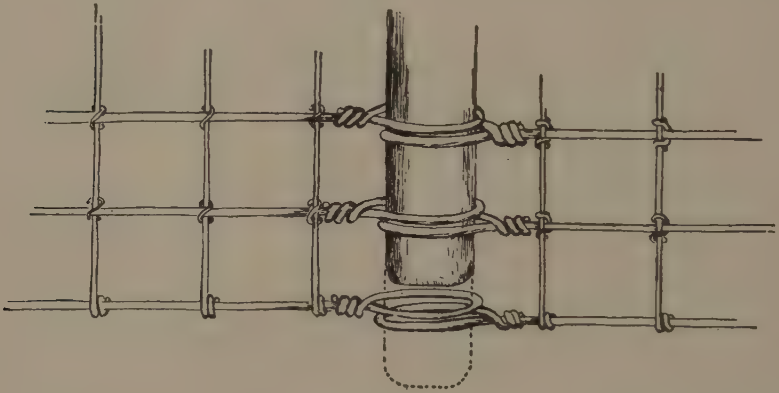


FIG. 29

Two rolls of fencing joined by use of the stake. Convenient for a temporary fence. (Courtesy University of Minnesota.)

The staples should not be driven in their full length, because they may crack the galvanizing and cause the wire to begin to break at this point. Furthermore, it is very difficult to draw out staples driven in the full length.

CHAPTER II

PAINTING

Paint is primarily used to protect wood and metal surfaces from decay and rust. Because of the improved appearance which a good job of painting gives to a building, the decorative value seems to outweigh the purely protective advantages of paint.

White lead and linseed oil make the highest quality of paint. If carefully put on, it seldom peels, and when later coats of paint are to be added, it will be found that the surface has worn down smoothly. This does away with the labor of scraping the surface and the possibility of needing to burn or to scrape the old paint off because of a rough and lumpy surface. White-lead paints are usually slightly more expensive than other paints, and for this reason are more often used for house painting than for the common buildings found on the farm.

Ready-mixed paints of high quality have found a wide sale and use, because of the excellent results obtained and the ease with which they may be handled. The better paints carry white lead as their base. Reliable manufacturers guarantee their products.

For painting metal surfaces, special paints are required. These paints carry a base of red lead or graphite, depending on the conditions to which the paint is to be subjected. The red-lead base paints are used most frequently on structural steel, while the graphite is used where the paint will be subjected to extreme heat, as on boilers. Ready-mixed metal paints may be purchased in a variety of colors.

JOB 10

PURCHASING THE PAINT

General information.

The covering capacity of paint depends entirely upon the condition of the surface to be covered. A badly weathered or chalky surface requires a paint that contains more oil than one which shows signs of peeling.

Procedure.

1. *Use of home-mixed paint.* White lead may be purchased in containers holding amounts ranging from five pounds up to 100 pounds. The linseed oil is purchased separately and the two are mixed on the job. When a color other than white is desired, any color may be obtained by the purchase of tints, as described near the close of the directions of this job.

2. *Use of ready-mixed paint.* This has the advantage of being uniform in color and furnishing just the shade wanted when it is bought. It is easy to prepare, because it requires only stirring and the addition of linseed oil and turpentine according to the coat one is applying. For good results, it is necessary to get a high quality of paint.

3. *Use of common barn paint.* Barn paint comes in all grades and qualities. For this reason it is particularly desirable to get it from reliable dealers who will guarantee their products. High grades will be very satisfactory, while the poorer grades will not only be worthless for protection, but will result in a loss of labor.

4. *Use of raw linseed oil for outside work.* The raw oil will dry more uniformly throughout than the boiled linseed oil.

5. *Boiled linseed oil.* This oil dries from the outside, forming a thin coat on the outer surface before it is thoroughly dry, and does not penetrate as deeply as the raw oil. It is not as satisfactory for outside painting as the raw linseed oil.

6. *Using color.* When color other than white is desired, tinting may be done by using colors ground in oil, which may be added to the lead little by little until the desired color is obtained. The principal colors used for tinting purposes are as follows:

- Reds
  - Vermilion
  - Venetian
  - Tuscan
  - Indian
- Yellows
  - Chromes
    - Light
    - Medium
    - Dark
  - Ochre
    - Yellow
    - French
- Blues
  - Prussian
  - Cobalt
  - Ultramarine
- Browns
  - Raw and burnt sienna
  - Raw and burnt umber
  - Vandyke

Add black where required to get darker or grayed colors.

JOB II

PURCHASING A PAINT BRUSH

The importance of a high quality of paint brush is seldom realized. The first cost is too often the deciding factor in the selection of a new brush, and a poor brush may ruin the quality of the work done.

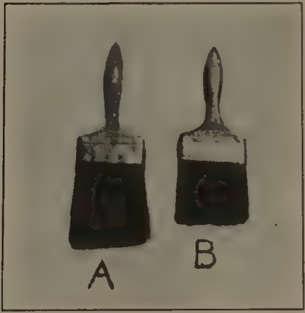


FIG. 30

Paint brushes: (A) Long, springy bristles in a good brush. (B) Short bristles of a poor-quality brush.

Procedure.

1. Select a brush with thick, springy, firmly set bristles. The brush with a thick set of bristles will hold a larger amount of paint with less dripping and therefore less waste. Long, springy bristles will spread paint more evenly and smoothly. A good brush will outlast a cheap one. See Figures 30, 31, and 32.

2. Types of brushes for different uses:

a. For enamel, 1″-3″ rubber-set
    1″-1½″ sash tool
b. For undercoat, 1″-4″ flat wall brush
c. For wall painting, 1″-4″ flat wall brush
d. For varnishing woodwork, 1″-6″ oval brush
e. For varnishing floors, 1″-8″ oval brush
f. For outside painting, a leather-bound brush is considered the best, although a flat wall brush may be used successfully

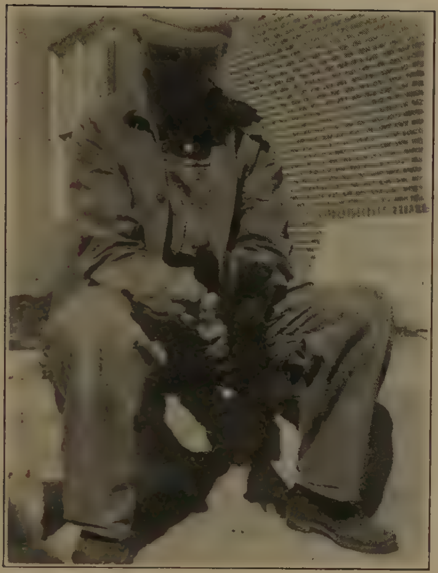


FIG. 31

A good brush has a thick set of bristles throughout the entire brush. Compare with Fig. 32.

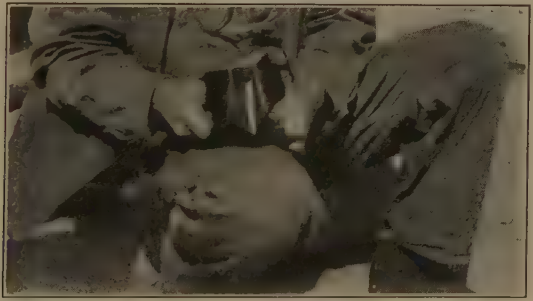


FIG. 32

The center of the brush is without bristles in a poor brush. Notice the wood block in the center.

CARE OF PAINT BRUSHES

Material and equipment.

Turpentine, benzine or kerosene.

Procedure.

If the paint in a brush is allowed to become hard, it is almost impossible to clean the brush, and the bristles will never be the same thereafter. It is often cheaper to throw away such a brush than to attempt to reclaim it.

1. After the painting job is complete, cleaning the brushes at once is important.

2. Soak the brush in turpentine or benzine or kerosene, working out the paint with a putty knife.

3. Brushes that are in use for several days may be suspended in the paint itself or in linseed oil while not in use. See Figure 33.

4. A brush suspended in oil or paint should always hang so that it does not rest on its bristle ends. Drill a small hole through the handle of the brush near the top of the ferrule, and put a wire through the hole. The wire, extending across the top of the oil or paint container, prevents the brush from resting on its bristles. See Figure 33.

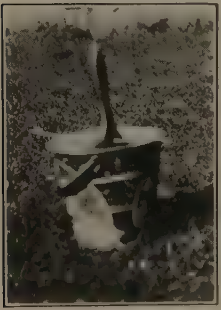


FIG. 33
Paint brush suspended in linseed oil when not in use.

5. Straighten out the bristles and allow the brush to dry.

6. Wrap the bristles carefully in oil-paper or other heavy moisture-proof paper.

7. Hang the brush up so that danger of bending the bristles will be avoided. If it is not hung up, caution should be taken to see that the bristles are allowed to lie straight.

8. Putting a brush in water will cause the bristles to lose their springiness. Therefore, never put a brush in water in the attempt to wash it or to keep it in good condition.

9. Brushes that have been allowed to become hard may be reclaimed by the use of "Save-a-Brush" or other patent compounds for sale by all paint dealers. As a rule, when brushes are cleaned in soap and water they are too soft for good work, and the use of "Save-a-Brush" applies only to the care of brushes that have been used for some time in paint.

JOB 13

PREPARING THE PAINT FOR PAINTING

Material and equipment.

Paint; turpentine; linseed oil; containers for paint; paddle for stirring paint; cheese-cloth; wire strainer.

Procedure.

1. Mix enough paint to cover the entire building.

2. Open the full head of the paint container. Pour off the free oil.

3. With a broad, flat paddle, begin by lifting the paint settled on the bottom. Work the paint until it is a paste of uniform consistency. Gradually add the oil that was poured off, stirring the contents thoroughly to assure complete mixing. When all the oil has been added, pour the entire contents from one pail to another until thoroughly mixed.

4. Strain the paint through a cheese-cloth or a wire strainer before using. Strained paint spreads farther, and lumps are eliminated.

5. The several brands of paints require varying additions of oil and turpentine. If the paint is from reliable manufacturers, the suggestions for adding turpentine and oil recommended by them should be followed. Their directions accompany all the materials.

6. To tint paint, take a small quantity of the white on a piece of glass or tin, and add a little tint until the desired shade is obtained. This will give you some idea as to the quantity of tint needed to color the entire batch and will eliminate the possibility of mixing too much paint, a mistake frequently made when the tint is added to the whole batch.

JOB 14

PAINTING NEW BUILDINGS

Material and equipment.

Paint; brushes; ladders; brush for cleaning wood; paddle for stirring paint; paint pails; paint-pail hook.

Procedure.

New wood: The temperature should be from 60° to 80° F. for the best results.

1. *Priming coat.* The paint for the first or priming coat must be such that it will penetrate the wood. If the paint contains too much pigment, the oil penetrates the pores of the wood, leaving the pigment on the surface. The result is that this coat of pigment will peel and the job of painting therefore will be unsatisfactory. Usually a gallon of raw linseed oil and a pint of turpentine are added to each gallon of paint.

2. The surface to be painted must be dry and free from dirt. If any knots and pitchy places are found it is necessary to cover these with one coat of shellac. The shellac will keep the pitch from being drawn to the surface and will form a foundation for the paint. The resinous places do not absorb paint as the other wood does. Where three coats are to be applied, the best results are obtained by the use of aluminum paint in place of shellac. The former is not so likely to peel off.

3. Begin painting at the highest point and work down. Paint a strip across the building, and continue in this manner until the bottom is reached.

4. In putting on the paint, brush it out so that the brush laps do not show. This may be more easily accomplished by the use of a high-quality brush, for it will hold the paint and allow it to flow out gradually. A poor-quality brush drops the paint at the

beginning of the stroke, and it is thus practically impossible to get it spread evenly.

To avoid getting too much paint on the brush, dip it only halfway or less into the paint, depending on the amount desired. When taking the brushful of paint out of the pail, lightly draw the brush across the edge of the pail to remove the surplus on one side, then turn the brush, repeating the operation, to remove the surplus on the other side. In beginning the stroke of the brush, apply it to the lower edge of the clapboard. Brush out carefully and then cover the flat surface of the clapboard.

5. After the priming coat is complete, *putty all nail holes.* Knead the putty until it is soft and works well. When it is not being used, keep it stored in a tight container to prevent it from drying out and hardening. Kept in this manner, it will remain soft for an indefinite period. Lead putty for painted surfaces is best when made of lead in oil, dry lead, or whiting.

6. When the priming coat is dry, the job is ready for the *second coat.* It is highly desirable to put this on soon after the priming coat, because if the latter is left for a long period, weathering takes place, and the second coat is little better than a second priming coat. If the priming coat is left for a period of months, it is possible that the accumulation of dust and dirt will prevent the proper adhesion of the second coat.

7. *The second coat.* The paint for the second coat is thicker than that for the priming coat. Usually about one-half gallon of linseed oil and one-half pint of turpentine are added to each gallon of paint. If only two coats are to be put on, the addition of the oil and turpentine may be omitted. The procedure for applying the paint is the same as for the priming coat.

If trim is desired, put it on with this coat, bringing it down with the other paint. This saves the time of moving the ladder over the ground a second time and avoids marring the newly painted surface by leaning the ladder against it.

8. When the second coat is dry, the *third coat* is applied. Follow the same procedure as in putting on the second coat. The paint is thicker, and the addition of linseed oil is omitted.

JOB 15

REPAINTING BUILDINGS

Material and equipment.

Paint; brushes; ladders; paint pail; paint-pail hook.

Procedure.

1. See that the dirt and rough places are all scraped off. If the old paint is lumpy and peeling, it will be necessary to remove it before the new paint is applied.

2. Touch up all the bare spots with a coat of the paint mixed for the first coat. This will smooth out the surface, so these bare spots will not show through the finished job.

3. If the old paint is glossy, the new paint may "crawl." That is, it may not remain evenly over the surfaces as left by the brush. A pint of turpentine added for each gallon will usually correct the trouble. If turpentine does not keep the paint from crawling, add a tablespoonful of ammonia to each gallon of paint.

4. Two coats are all that are usually needed for old work, for the old paint serves as the priming coat.

JOB 16

PAINTING MACHINERY

Material and equipment.

Steel brush; scraper; mineral paint; wood paint; round brush.

Procedure.

1. Remove all dirt, dust, grease, scale or rust with a steel wire brush and scraper.

2. For best results on metal parts, use mineral paint, or mix your own paint, using a base of red lead.

3. Paint for machinery and iron surfaces can best be applied with a round (oval) brush.

4. Do all painting in a place that is clean and free from dust. A temperature of 60° to 80° F. is preferable.

5. Three coats of paint are necessary on all outside work if best results are expected. In no case will one coat of paint completely cover bare metal. Many air bubbles will be found, and even a second coat will not entirely cover all these small holes. Care should be taken to brush the paint out carefully in order to work out air bubbles, which cause small holes in the surface.

6. Bolts, rivet heads, edges, and corners provide many possible chances for rust to gain a foothold, so care must be taken to cover these parts thoroughly.

JOB 17

PAINTING THE AUTOMOBILE

Material and equipment.

Metal primer; colors ground in Japan rubbing varnish; finishing varnish; pumice-stone; chamois skin.

Procedure.

1. Make sure that there is no dust in the room and that the automobile is entirely free from dirt and dust.

2. If the old finish is cracked and peeling, it will be necessary to scrape off the old paint or to remove it by using a varnish remover.

3. If a *varnish remover* is used, make it as follows: Take one-half gallon of benzol, one-half gallon of alcohol and one-fourth pound of paraffin. Heat the paraffin, add it to the benzol and stir; then add the alcohol. This will remove everything but baked enamel, and may be made the same for all surfaces.

4. If the old paint film is intact and only the varnish is broken, the following method may be used. Clean parts thoroughly. Be sure all grease and grit are removed. Use wire brush and scrapers to remove broken varnish. A light rubbing with powdered pumice-stone and water will then smooth the surface.

Prime the metal with red lead or some other prepared metal primer, after getting the car ready for painting, and before applying the paint.

6. Sand lightly and putty all file marks with a varnish putty. "Krackno" or some similar prepared putty is very good for this purpose. An even surface must be obtained before any color is applied.

7. Sand again and coat with Japan color. Purchase only

material bearing the name of a reliable manufacturer. Thin the color with turpentine and apply with a soft brush.

8. Rub the color when dry with curled hair and proceed to put on *rubbing varnish.* Use an oval brush and see that the temperature is between 70° and 80° F.

9. After rubbing varnish is thoroughly dry, apply *finishing varnish,* and after forty-eight hours or longer, sponge with water to set the gloss.

References.

Harn, O. C. *Handy Book on Painting,* National Lead Co., New York, 1923.

CHAPTER III

BRICK AND BRICKLAYING

General information.

Brick are commonly used in buildings because those of good quality last a long time. They are good insulators, strong and of pleasing appearance. A building made of brick needs practically no repairing after it is once completed.

The cost depends upon the location of the building. If the building is to be close to where brick are made, they will cost no more than any other kind of construction material.

1. *Laying the brick.* Bricklaying in itself is not very difficult, but a bricklayer is always expected to lay a certain number of brick in a day; and in bricklaying, as well as in other trades, speed cannot be reached without long training and experience. However, if it is a matter of doing the work regardless of speed, anyone with some knowledge of the repair and upkeep of buildings should be able to lay brick after a little practice.

2. *Kinds of brick.* Brick are generally classified as face brick and common brick. Brick vary in quality, and care should be taken to get a good quality made by a reliable manufacturer. A face brick may look well in a wall but be of a poor wearing quality. On the other hand, a common brick may not appear to be good but may be very strong. Each kind has its place.

3. *How to judge brick.* The quality of the brick is judged by its soundness. The less water it will absorb, the better the brick.

A good brick should have a clear ringing sound when struck with a hammer.

4. *Building with brick.* If building with brick, be sure to have a good foundation or footing. A foundation or footing that reaches below the top black soil is considered strong enough for small buildings, such as garages and chicken coops, and for brickwork such as steps and gate-posts. Other buildings, such as

houses or barns, are, as a rule, carrying heavy loads, and should have foundations that reach below the frost line.

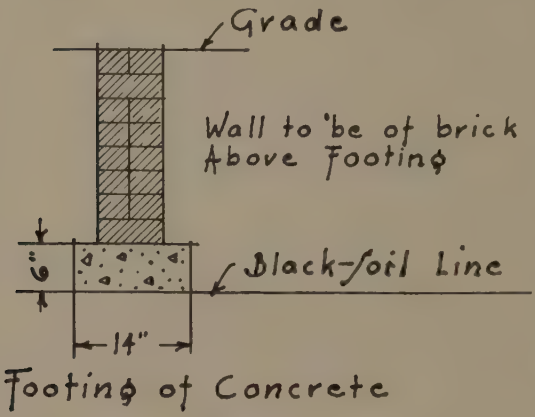


FIG. 34
Brick wall with concrete footing.

5. *Footings.* Footings can be made of stone, brick or concrete. One is as good as another; the cost of the material is the deciding factor in determining which one to use.

It should be remembered that if concrete is used, lumber and labor are needed for making forms, which are unnecessary when using stone or brick.

The purpose of the footing is to support the load of the building. The carrying capacity of the soil determines the width and thickness of the footing, as the purpose of the footing is to transfer the load of the building to the soil.

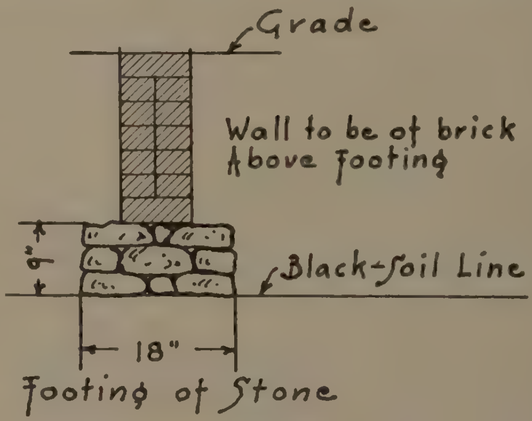


FIG. 35
Brick wall with stone footing.

6. *Width of footings.* A footing that is six inches wider than the wall resting on it is considered strong enough for a small building.

For taller buildings, a footing should be twelve inches wider than the wall which is resting on it.

7. *Thickness of footings.* The thickness of the footing also depends upon the size of the building that is to be supported. It varies from six to twelve inches. Footings of small buildings, if made of concrete, as are shown in Figure 34. If the footings are made of stone, Figure 35 illustrates the method of construction. Brick footings are made as in Figure 36.

Footings for houses and barns are the same in shape as for smaller buildings; but the walls of the larger buildings will be twelve inches thick, so the footings will be wider and thicker, and should reach below the frost line to be safe.

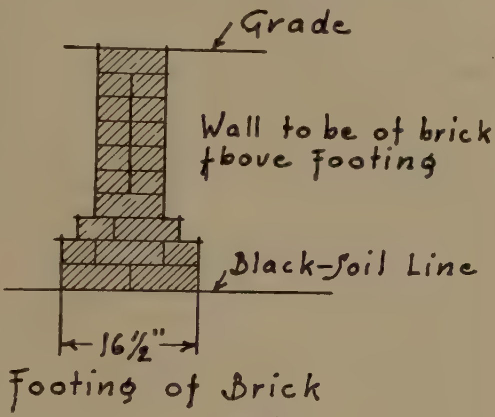


FIG. 36
Brick wall with brick footing.

8. *How to estimate brick construction.* Brick work is figured by the square foot. Allow seven brick for each square foot, when the wall is four inches thick. Allow fourteen brick for an eight-inch wall and add more brick in proportion for a thicker wall. Deduction should be made for openings in walls.

One barrel of bulk lime is required for each thousand brick. If hydrated lime is used, one and one-half barrels should be allowed.

For outside brickwork and for brick laid below grade, allow one-half barrel of cement for each thousand brick. About one yard of screened sand is needed for each thousand brick. Screened bank-run sand is best for brickwork.

JOB 18

LAYING OUT A FOUNDATION

Material and equipment.

Stakes; line; hand ax; tape.

Procedure.

1. Set stakes where one side of the building is to be.

2. Stretch a line between the stakes, the line to represent the front of the building.

3. Mark on the line where one corner of the building is to be and set two more stakes, stretching a line between these stakes. This line is to cross the first line where the corner is to be, as in Figure 37, and is to represent the side of the building.

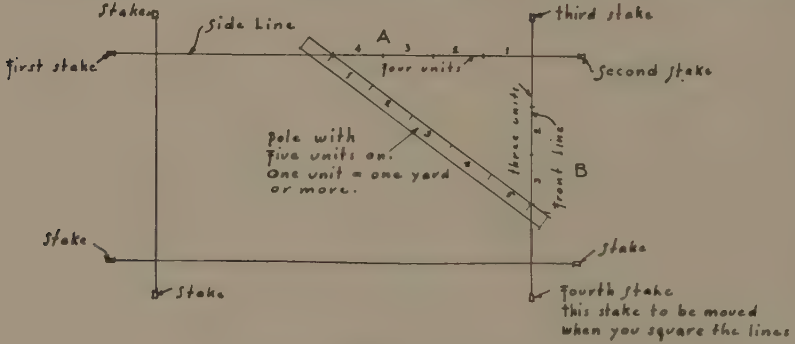

Stake
Side Line
A
4
3
2
1
third stake
first stake
four units
Second Stake
three units
front line
B
Pole with five units on. One unit = one yard or more.
1
2
3
4
5
Stake
Stake
Stake
fourth stake this stake to be moved when you square the lines

FIG. 37

How to square a foundation.

4. Before proceeding further, it is necessary to square these lines.

The easiest way to square the lines is to use the 3-4-5 measurements. This is accomplished by measuring off four units from the corner. See Figure 37. Then, starting on the line representing the front of the building, measure three units from the corner. Now measure off five units on a pole, holding that pole from the side line to the front line. Move one end of the front line until the marks on the pole and the marks on the lines meet, making a right triangle, as shown in Figure 37.

5. After these lines are squared, measure the width and length of the building on the lines, set four more stakes and stretch two more lines for the exact shape of the building, as shown in Figure 37.

Remember to put the stakes far enough away so that they will not be dug out during excavation for the foundation or footings.

6. After the lines are set correctly, establish the grade, then dig the trenches for the footings. Remember that the lines represent the outside of the walls for the building, so excavate enough outside of the lines to get room for the footings.

7. Keep the trenches level in the bottom after the desired depth is reached, whether it is to be below the black-soil line or the frost line.

JOB 19

PREPARATION OF MORTAR FOR BRICKLAYING

Material and equipment.

Box 3′ wide, 5′ long and 8″ deep; bulk lime; water; mortar hoe; water pails; barrel, 30-gallon capacity.

Procedure.

1. Do not prepare too much mortar at a time.

2. Slake the lime. Bulk lime requires slaking.

Put one-fourth barrel of lime in the box; put water on it until half of the lime is covered. Then let it rest until it starts to steam and boil. Stir slowly and add more water gradually until the mixture stops boiling, when the lime is slaked.

Do not let the lime boil dry, for that will spoil it. Be sure to have plenty of water on hand before starting to slake, because when the lime starts to boil, it is necessary to add water and keep stirring continually.

If lime is slow to slake, put less water on in the beginning.

Bulk line increases about three times its volume when slaked.

When the lime is slaked, it is called lime putty and should be of the consistency of soft butter.

3. Move the lime to one end of the box, pile it up and put a sand-bank in front of it to hold it there.

4. Mix the mortar. Lime-cement mortar is a mixture of one part cement, seven parts screened sand and two parts lime putty.

a. Put twenty-eight shovelfuls of sand and four shovelfuls of cement in the box. Mix well.

b. Add eight shovelfuls of lime putty and stir, adding water as needed, until mixed thoroughly.

Mortar should be neither too thin nor too thick when shoveled;

it is of the proper consistency when it will stand three inches high on the shovel without running off.

In warm weather, if it should harden before it is entirely used, put water on and remix it. It will not deteriorate if softened in the morning.

If some is left overnight, add a little more cement to it and mix it again. It is again ready for use.

5. Make two or three mortar-boards. A good mortar-board should be thirty inches square, but any thing that will hold the mortar may be used, such as an old door, or it may be left in a wheelbarrow and taken out with a trowel.

JOB 20

LAYING THE BRICK

Material and equipment.

Mortar; mortar-board 30″ square; 11″ trowel; level; shovel; hatchet; brick.

Procedure.

1. Take the brick to where they are to be used. Only good, hard-baked, common brick should be used below the grade. The hardness and not the appearance of the brick should be considered.

Place the brick and the mortar so that they can be reached as you stand in the trench.

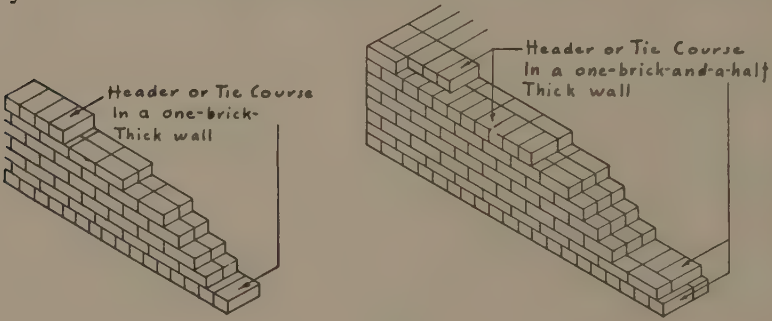


FIG. 38
Laying the brick wall.

2. Step down in the trench. Take a plumb-bob or a spirit-level and hold it at a point where the lines cross. Plumb from that point down to the bottom of the trench. Set a nail or a small stake to show the mark in the earth and from there measure out for the footing.

3. Get the trowel and put a three-fourths inch mortar bed on top of the dirt in the bottom of the trench. Place the brick in it as shown in Figure 38.

4. Build up the corners first; then stretch a line from corner to corner. This will make it easier to get the wall straight.

The appearance of the wall is not of great importance, as it will be covered up, but be sure to have all of the joints full of mortar, because the strength of the wall depends upon that.

If the wall should get out of level, it can easily be leveled by making the joints thinner at the high point and thicker where it is low.

Check for level often, so it can be corrected before the wall gets up to grade. The wall should be level at the established grade.

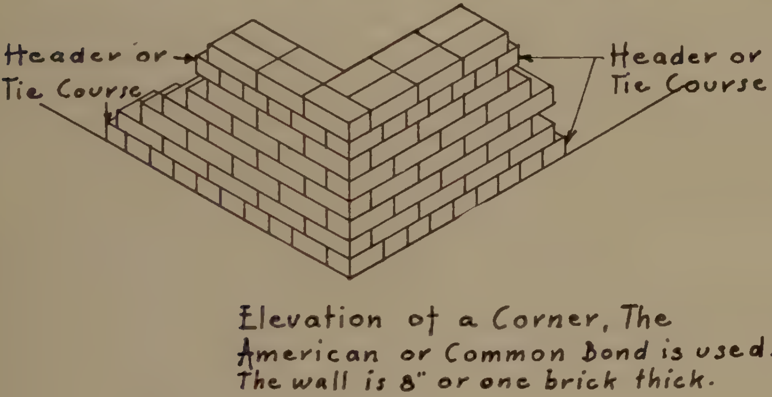

Header or Tie Course
Header or Tie Course
Elevation of a Corner, The American or Common Bond is used. The wall is 8" or one brick thick.

FIG. 39

Construction of the corner of the brick wall.

5. If the upper structure is to be of brick, proceed as before. Build the corners first; use a line and lay the brick. See Figure 39. Spread the mortar about three-quarters of an inch thick. Press the brick down into the mortar until the joint is one-half of an inch thick. The mortar that is pressed out when the brick are laid is scraped off with the trowel and put on the edge of the brick that will fill the cross point for the next brick that is to be laid.

More care should be taken with the laying of the brick for the upper structure, as errors will show.

JOB 21

TO REPAIR OLD BRICKWORK

Material and equipment.

Mortar; mortar-boards 30″ square; 11″ trowel; level; shovel; hatchet; brick.

A. Repointing Joints That Have Fallen Out in Old Brick Walls

Procedure.

1. Clean all loose mortar from the joint. Sweep it with a broom and then dash it with water. The water will moisten the old joint so that the new mortar will hold better.

2. Mix the mortar as described before. Take some mortar on the back of a brick trowel and set the edge of the trowel to the edge of the brick so that the joint that is to be filled is above the trowel. Push the mortar off the trowel into the joint with a piece of lath or something similar. Fill in two feet at one time, then smooth the surface of the joint by sliding the brick trowel over it, pressing as hard as possible.

3. Coloring may be put into the mortar so that it will match the old work and then the repair job will not be conspicuous. Coloring may be obtained where the brick is purchased.

B. Chimney-Top Repairing

Procedure.

1. Remove all loose brick.

2. Be careful to observe how the brick are laid before removing them. If the same brick are to be used again, it would be wise to place them on the scaffold or on the ladder in a certain way so that each brick can be put back in its original position. In this way it will be easier to build the chimney again and it will be possible to make it the same size and shape as before.

3. If there is a flue lining in the chimney, fill solidly between the brick and the lining.

If there is no lining, plaster the chimney inside, adding a little more cement to the mortar. Cover the chimney on top with cement mortar.

Cement mortar should be mixed in the proportion of one part of cement to three parts of sand.

C. Cutting Openings in Brick Walls

Procedure.

1. Decide first how large the opening is to be. Have frames made before cutting. Mark off on the wall the size of the frame.
2. Begin to cut close to the bottom of the opening that is to be made. Cut a small opening through the wall first. It will then be easy to enlarge the hole in all four directions as needed.
3. Cut the opening large enough so that the frame will fit in tightly. Do not leave any brick that are cut. Remove all pieces at the sides of the opening so that only whole brick are left.

Do not jar the brick in the wall more than necessary. Hard blows do not help. Use a chisel that is made of three-fourths inch steel and an ordinary hammer. If the cutting is done carefully, no support will be needed to hold the brick at the top.

4. If the opening is four feet or more wide, the brick at the top should be supported.

Place the frame in the opening, putting it close to the top. Put loose brick under it to hold it in position. Brick up the sides, fitting the brick close to the frame. Let dry and then fill in under the frame.

CHAPTER IV

CONCRETE

Concrete is a very convenient material to use in construction work on the farm, for it is easy to make and simple to use. It can be made up in a variety of ways, and because of its economy, adaptability, and permanence, it can be freely applied to all kinds of farm construction, both in new work and in repair jobs. When properly made, it has remarkable strength; it is rat-proof, rot-proof, and storm-proof, all especially valuable qualities.

Concrete is a mixture of Portland cement, aggregate, and water, which, when allowed to harden, forms an artificial stone. Portland cement is fine powder made by grinding a definite mixture of certain kinds of stone which has been heated to a very high temperature before grinding; when mixed with water it has the property of hardening and binding materials firmly together. Aggregate, which makes up the bulk of concrete, includes sand, pebbles, broken stone, slag, cinders, or any other similar hard, durable material.

When a standard brand of Portland cement is bought from a reliable dealer, it can be accepted as satisfactory, for it is made to accord with rigid specifications definitely established. Selection of an aggregate, however, must be made carefully, since much depends on the size of the particles, their grading or variation in size, and their quality; cleanliness and freedom from organic impurities are essential. So far as water is concerned, that which is fit to drink is suitable for use in concrete.

The *proportions of the different ingredients* vary according to the character of the work. Concrete is strongest in compression; therefore, when this is the only strain that will come upon it, as in the case of a horse-block, a rich mixture is not necessary; but a fence post, for instance, which is subject to bending, must be made very strong, and not only must a rich mixture be used, but steel reinforcing must be put in the corners, to increase the strength. Common mixtures are as follows—the number of parts of cement always being given first; the number of parts of sand, or fine aggregate, second; and the number of parts of coarse aggregate, consisting of pebbles or broken stone, last:

1-2-2 —Mixture for posts, walks, floors, tanks, and the like.
1-2-4 —Mixture for engine bases, scale pits, hotbeds, and the like.
1-2½-4—Mixture for walls, footings, foundations, and the like.

Mixing may be done with shovels on a mixing board, or with a small machine mixer. When it is done by hand, the following procedure is usual: Using a bottomless box of known size, measure out the desired amount of aggregate and place the proper quantity of cement in a depression in the aggregate pile. Turn this over several times until it is thoroughly mixed, and the mass is of uniform color. Then add water and resume the shoveling, continuing it until every particle of the aggregate is covered with a film of wet cement.

Small amounts of cement and aggregate for concrete to be used in making small objects, can sometimes be mixed on a discarded drawing board or in a pan with a mason's trowel instead of a shovel. More than can be used within a half hour should not be prepared, since setting of the cement is likely to begin to occur.

Forms in which the concrete is molded are usually made of wood or metal. The former is used for general farm concrete work such as walks, steps, foundations, tanks and so on, while the latter is common in forms that are to be used over and over again, as with monolithic silo forms and molds for concrete blocks. Wood forms should be smooth on the side next the concrete, and should be firmly braced so they will not bulge; all forms should be coated on the inside with oil or soft soap each time before using, to prevent the concrete from sticking to them.

Since concrete begins to harden soon after water is applied to the mixture, it follows that there must be no delay in placing it in the forms after mixing. Tamping helps to compact the mixture and fill the corners of the mold; sometimes shaking or vibrating is employed for the same purpose. Spading, or inserting a flat spade between the concrete and the inner face of the form and working it back and forth to push the larger aggregate particles away from the surface, helps the appearance of the finished concrete. As a rule, forms must not be removed for from twenty-four to forty-eight hours, depending on the weather and the character of the work. Daily soaking with water for several days, protecting against the hot sun and freezing cold, will improve the quality of concrete. Concreting in freezing weather is practicable, provided the materials are heated and the concrete is protected from frost for forty-eight hours after mixing.

JOB 22

TO CONSTRUCT A HITCHING BLOCK

Material and equipment.

Cement; sand; pebbles; water; oil; tin can or pail of about 1-gallon capacity; heavy staple with bent ends; small mixing board; trowel; quart measure.

Procedure.

1. Oil the inside surface of the can.

2. Measure out four quarts of pebbles and two quarts of sand, and put one quart of cement on top of the pile. Mix thoroughly.

3. Add water in small quantities, at the same time mixing the mass well, until it of a uniform consistency, just stiff enough to hold its form when piled.

4. Fill the can with the concrete, tamping it in well. Insert the staple so it will project an inch or more above the surface, which should be smoothed off with the trowel, and beveled along the edge. See Figure 40.

5. Allow the concrete to harden for twenty-four hours.

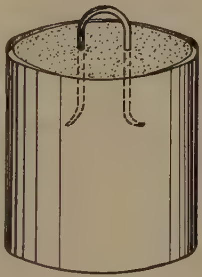


FIG. 40
Hitching block.

6. Remove the can, using chisel or tin-snips if necessary. (The can may be left on, if desired.)

7. Cure for at least one week, wetting thoroughly every day.

JOB 23

TO MAKE A FOOT SCRAPER

Material and equipment.

Cement; sand; pebbles; water; oil; small mixing board; trowel; quart measure; two smooth boards, 2″ x 8″; two smooth boards 2″ x 14″; one board, 8″ x 12″; three strips of metal ⅛″ x 1″, riveted as shown in Figure 41.

Procedure.

1. Nail the pieces of wood together to form a box eight inches wide, twelve inches long, and two inches deep, inside measurements.
2. Oil the interior surface of the box.
3. Using the quart measure, measure out four and one-half quarts of small pebbles and three quarts of sand, and put one and one-half quarts of cement on top of the aggregate pile. Mix well.
4. Add water in small quantities, mixing the mass well in the meantime, until it is all wet, yet sufficiently stiff to hold its form when piled.
5. Put the concrete in the box, inserting a metal strip in the center of the concrete as shown in the sketch, Figure 41. Smooth the surface of the concrete with a trowel, trimming off the edges.
6. Allow this to harden for at least forty-eight hours.
7. Dismantle the form and remove the block.
8. Fill any holes in the sides with rich cement mortar, made by mixing one part of cement with one part of sand and adding enough water to make a workable mass.
9. Cure for at least one week, wetting concrete thoroughly daily.

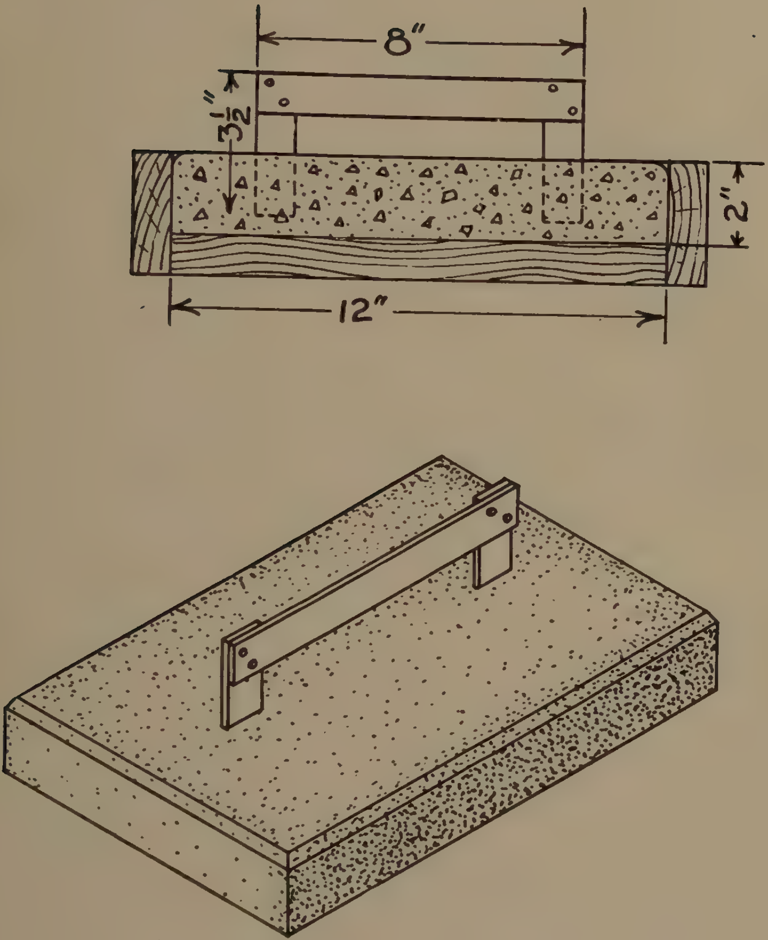


FIG. 41
Foot scraper.

JOB 24

TO MAKE A CONCRETE FENCE POST

Material and equipment.

Cement; sand; pebbles, the largest ¾″ in size; water; oil; trowel; mixing board, 6′ x 8′; 2″ x 4″ tamper; shovel; bottomless measuring box, of 1 cu. ft. capacity; eight ¼″ reinforcing rods, 6′ 6″ long; post forms, either of commercial type or home-made. If home-made, the form should be made of three boards, each 1″ x 5″ x 7′ for the sides, and two cleats 1″ x 5″ x 14″ for the ends, assembled as shown.

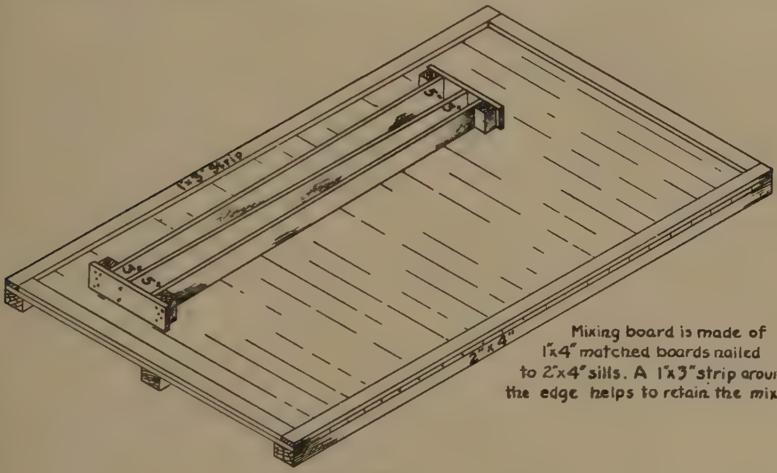
General information.

Proper mixture and placing of reinforcing is of prime importance.

Procedure.

1. Assemble forms, placing them on the mixing board at one side, and grease the interior. See Figure 42.
2. Using the measuring box, measure out one and one-half cubic feet of pebbles and one cubic foot of sand, and put one-half sack of cement on top.
3. Mix dry materials thoroughly.
4. Add about two and one-half gallons of water, and again shovel the mixture over and over very thoroughly until all of the elements are completely incorporated. If the stated amount of water is not sufficient to produce a plastic mixture of the consistency of thick mortar, add more in very small quantities, continuing the mixing until such a consistency is developed.
5. Oil the sides and the bottoms of the forms carefully.
6. Deposit enough concrete in the forms to make a layer three-fourths inch thick when tamped. Lay a reinforcing rod along

each edge of both posts, about three-fourths inch from the edge. Add enough more concrete to fill the forms within three-fourths inch of the top, tamp well, and place two more rods in each post about three-fourths inch from the edges. Fill the molds with concrete, run the trowel along the edges of the mold to force the larger particles of aggregate away from the sides, then tamp well and smooth the top surface.



Mixing board is made of 1"x4" matched boards nailed to 2"x4" sills. A 1"x3" strip around the edge helps to retain the mix.

FIG. 42

Post form set up on a mixing board.

7. Allow the concrete to remain in the mold for at least twenty-four hours, better forty-eight hours.

8. Dismantle the form and stand the posts on end in some place sheltered from the wind and sun.

9. Cure for thirty days, wetting the posts thoroughly each day; then they are ready for use.

JOB 25

TO MAKE A HOG TROUGH

Material and equipment.

Cement; sand; pebbles; water; oil; mixing board; tamper; shovel; bottomless measuring box; inside and outside forms made as shown in diagram, Figure 43.

General information.

Making a hog trough involves the making of a water-tight structure.

Procedure.

1. Put the inside form in place upside down on the mixing board, at one side. Set the outside form in place, taking care that inside and outside forms are properly centered.

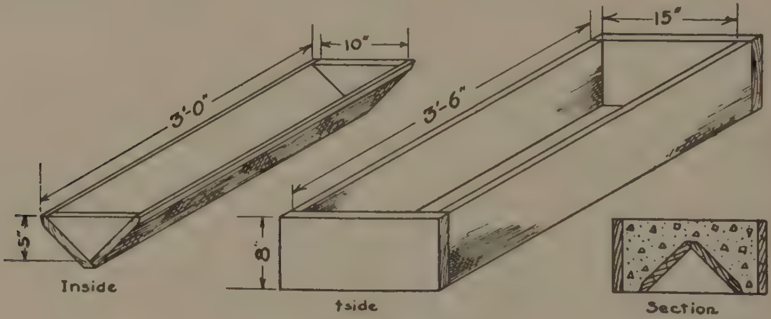


FIG. 43

Hog-trough forms.

2. Grease well all surfaces with which the concrete will come in contact.

3. Measure out two and one-fourth cubic feet of pebbles and one and one-half cubic feet of sand, and place a little more than

three-fourths sack of cement on the pile. (This is a 1-2-3 mixture.) Mix dry thoroughly.

4. Add slowly, stirring steadily, enough water to make a mixture of the consistency of damp soil. Thorough mixing is essential.

5. Place the concrete in the forms and tamp well, being careful not to displace the forms.

6. At the end of twenty-four hours, remove the outside forms carefully, lift the trough off of the inside forms, and fill up any irregularities in the surface of the concrete with a thick cement-water mixture brushed on evenly.

7. Cure for at least one week, allowing the trough to stand filled with water.

TO MAKE A SECTION OF SIDEWALK

Material and equipment

Cement; sand; pebbles, none larger than 1″; water; oil; mixing board; heavy tamper; shovel; measuring box; sheet of wrapping paper, 28″ x 40″; two pieces of lumber, 2″ x 4″ x 2′; two pieces 2″ x 4″ x 3′4″; wood float; edger; groover; straight-edge.

General information.

It is necessary to provide good drainage under the walk to prevent heaving by frost action. Walks are ordinarily made in blocks or sections four or five feet square.

Procedure.

1. Nail the two-by-fours together to form an enclosure two by three feet, inside measurements, and lay this on a sheet of paper on the floor. See Figure 44.

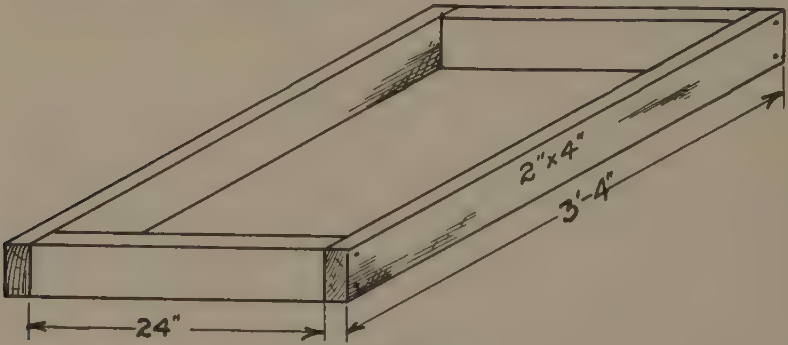


FIG. 44
Form for sidewalk block.

2. Oil the inside faces of the two-by-fours.
3. Measure out one cubic foot of sand and a little more than

one and one-half cubic feet of pebbles. Spread a little less than one-half cubic foot of cement over the pile. Mix dry thoroughly.

4. Add water slowly, continuing the mixing, until a stiff yet plastic mixture results.

5. Fill the form with the concrete, and tamp thoroughly until the finer particles are brought to the top.

6. Finish the surface with sweeping strokes of the wood float.

7. Run the edger at the sides to round the corners.

8. With the groover, form a groove squarely across the middle of the block, following the short axis, using the straight edge for a guide.

9. Allow to dry for at least twenty-four hours.

10. Remove the forms, and cure the block under moist conditions for one week before using.

JOB 27

TO MAKE AN ENGINE BASE OR FOUNDATION

Material and equipment.

Cement; sand; pebbles, up to 1½″ in size; water; oil; mixing board; heavy tamper; shovel; measuring box; trowel; form made like diagram (Figure 45), or any other size chosen by student; four ½″ bolts 6″ long; sheet of heavy cardboard, 20″ x 24″; sheet of wrapping paper 24″ x 36″.

Procedure.

1. Make a pattern, or template, of the engine base, as in Figure 45, setting the engine on the cardboard and, with a pencil, drawing in the outline. Locate carefully the foundation-bolt holes. Be sure that the engine is set approximately in the center of the sheet. Cut holes at the bolt points.
2. Set the foundation form on a sheet of paper and oil the inside faces of the form.
3. Measure out one cubic foot of sand and two cubic feet of pebbles, and spread one-half cubic foot of cement over the pile. Mix dry thoroughly.
4. Add water and mix until a fairly stiff, plastic mixture results.
5. Put the concrete into the forms, tamping well, until the forms are filled to within three inches of the top.
6. Place the template on the form, tacking at A, B, and C. Cut away part of the template as shown by the dotted lines.
7. Insert bolts through the bolt holes from below, letting the heads rest on the concrete already in place. See that the bolts are vertical.
8. Complete the filling of the form with concrete, being careful not to disturb the bolts. Tamp thoroughly.

9. Remove the template and trowel the surface of the concrete, cutting a bevel at the corners.

10. Let stand for twenty-four hours.

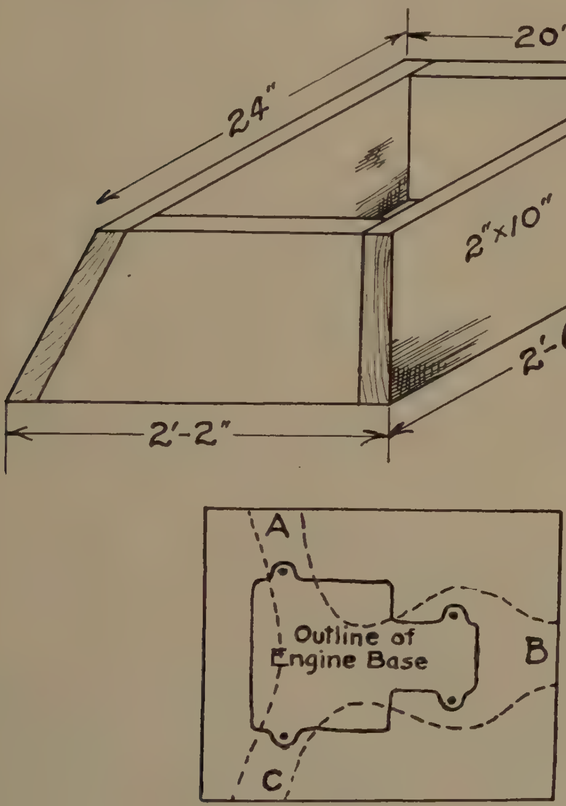


FIG. 45

Form and template for engine base.

11. Remove the forms.

12. Coat the exterior of the base with a thick cement-water mixture brushed on smoothly.

13. Allow to cure for ten days under moist conditions.

CHAPTER V

GLAZING

JOB 28

TO REPLACE A PANE OF GLASS IN A WINDOW SASH

Material and equipment.

Window sash with a broken glass; glass; putty; glass cutter; steel square; glazier points; primer; flat-top table or bench; turpentine.

General information.

Sheet glass varies in quality and thickness. What is known as "common" is satisfactory for the repair of the farm building windows.

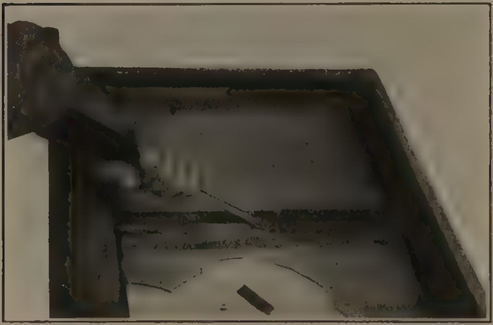


FIG. 46
Removing old putty.

Putty is composed of whiting and raw linseed oil; sometimes a little white lead is added. Putty often becomes stiff. To give it a good consistency, knead it well in the hands. If necessary, add a little raw linseed oil and mix it thoroughly.

Putty should be kept in a closed container to prevent it from hardening and becoming too dry. For small amounts, any tin container with a good cover, such as a coffee can or syrup pail, will be found very useful for keeping the putty in good condition for long periods of time. It may also be kept in a glass jar and covered with linseed oil.

Very often the priming coat has disappeared from the rabbet due to its being exposed to the weather. If putty is applied to a frame in this condition, the wood will draw the oil out of the putty and cause it to fall off. A good priming coat is composed of one quart of raw linseed oil, one pint of turpentine, and six pounds of white lead. A coat of pure linseed oil alone will also serve.

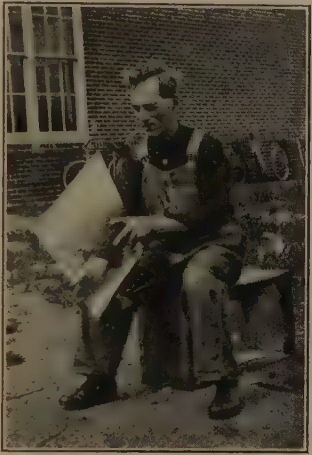


FIG. 47

Sighting along a piece of glass.

Procedure.

1. Remove the broken pane from the sash and clean out all putty and glazier points. Figure 46 shows a good method of removing the old putty. The large screw-driver is used as a chisel and is tapped with the hand as shown. Do not allow the end of the screw-driver to come closer than one-sixteenth of an inch to the wood frame while removing the bulk of the putty. Next scrape off the putty which still adheres to the wood with the screw-driver or putty knife.

2. Apply the priming coat to the rabbet if it is badly weathered.

3. It is usually best to cut the glass about one-eighth inch smaller than the opening it is to fill.

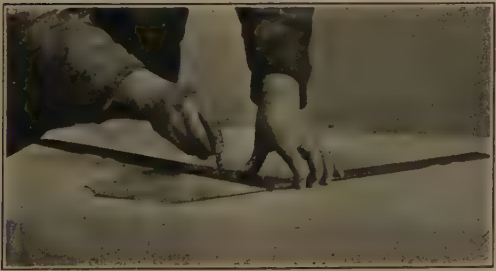


FIG. 48

Cutting a new pane of glass.

Measure the glass after measuring the frame, and cut it as follows: Sight along the edge as in Figure 47. Lay the glass down with the convex side up. This allows it to spring slightly when the pressure of the cutter is exerted on it. If the glass is put down concave side up, pressure of the cutter guide straightens it and takes out the springiness. The loss of the springiness causes the glass to crack and break easily when it is cut.

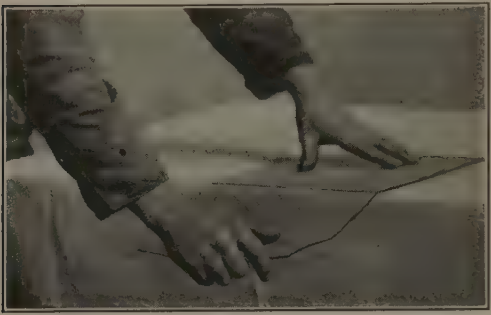


FIG. 49
Breaking the glass after it is cut by the glass cutter.

Lay the square at the proper place on the sheet of glass and hold the cutter as shown in Figure 48.

A light application of turpentine along the line where the glass is to be cut tends to minimize the amount of cracking and uneven breaking. Turpentine is particularly helpful where circular, diamond, or other oddly shaped glass is desired.

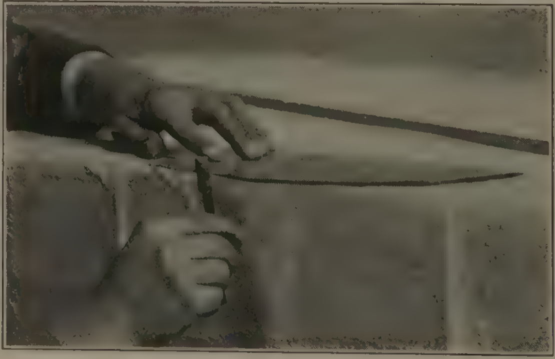


FIG. 50
Truing a rough edge on the pane of glass.

Start cutting the glass at the further edge, holding the cutter against the edge of the square; draw it straight toward you with a firm, even pressure. One rapid stroke will be sufficient, when properly made. A second cutting tends to make uneven breaks, and the glass breaks across the cut instead of on the line desired.

4. Place the line made by the glass cutter directly over the edge of a flat-topped table or bench. Press down gently on the part projecting over the edge of the table as shown in Figure 49. If the glass does not break readily, tap it lightly on the under side of the cut with the glass cutter.

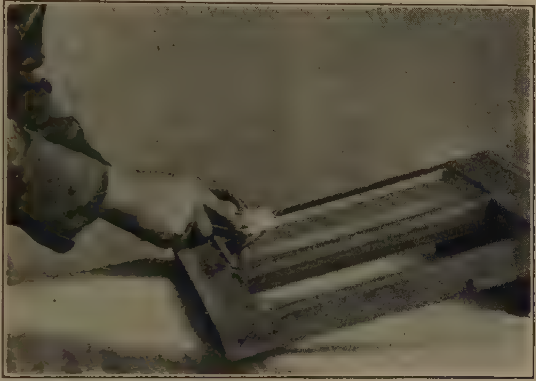


FIG. 51
Applying the putty.

5. If there are any irregularities on an edge, they may be broken off, as shown in Figure 50.

6. Place the pane in the opening.

7. Press the glazier points into the wood three-sixteenths of an inch, while holding the pane in place.

8. Apply the putty as shown in Figure 51. The putty is fed under the knife as it is drawn along. For one who does very little window repair work, it will probably be more satisfactory to distribute the putty first and then press it down.

CHAPTER VI

HARNESS REPAIR

The life of a harness is dependent upon its systematic care and repair. Any efficient farmer will avoid makeshift repairs such as tying his harness together with thong or baling wire.

With a small amount of instruction, the average farmer can, on rainy days or during the less busy seasons, make repairs which will not only add to the appearance, but will greatly increase the life and service of the harness. The following instructions are intended to help him to do the ordinary repair jobs needed on a harness. The local hardware stores usually keep a supply of harness repair parts such as straps, buckles, rivets, hame clips, loops, and snaps. Most of the repair work consists of putting these parts on the harness.

The following equipment will be found sufficient for all ordinary repair jobs: a stitching clamp for holding the leather; a riveting machine and tubular rivets; harness thread; wax pad made from a piece of thin leather 3″ x 4″ with shoemaker's wax on it; pocket-knife; haft and awls; needles; beeswax; revolving leather punch; and saddler's round knife.

JOB 29

TO MAKE A HARNESS THREAD

Material and equipment.

Linen harness thread; wax pad; beeswax; No. 10 needles; nail or hook to hold thread.

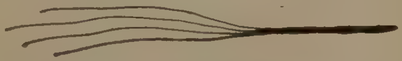


FIG. 52
Strands of harness thread.

General information.

The exposure, friction, and strain to which a harness thread is subjected necessitates great care in its construction.

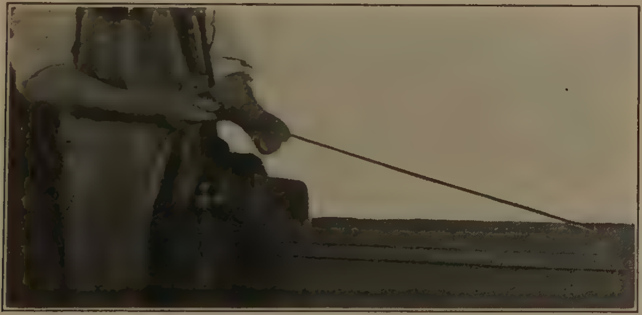


FIG. 53
Waxing harness thread.

Procedure.

1. Draw out a thread about five feet long.

2. Untwist the thread, which can then be easily pulled apart. Tearing is necessary to secure the long tapering end in the assembled thread.

3. Tear off four strands of equal length and place each succeeding strand a little further back from the tip of the assembled thread, as in Figure 52.

4. Throw the thread over a nail or hook in the bench and wax both ends by means of the wax pad, as shown in Figure 53.

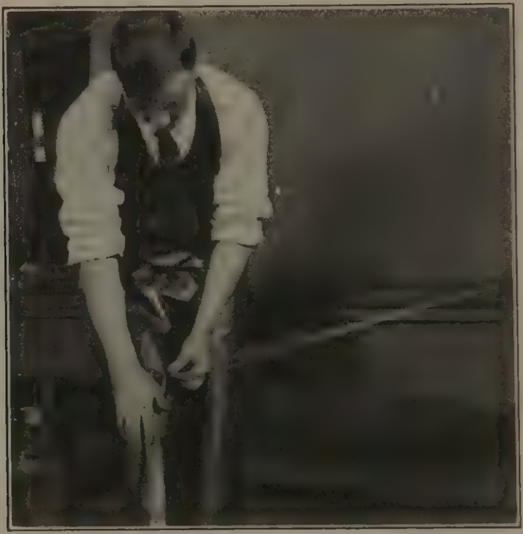


FIG. 54
Rolling harness thread.

5. Separate the waxed ends and wrap one end around the thumb or index finger.

6. Twist the thread by rolling the free end on the thigh as shown in Figure 54.

7. Twist both ends of the thread and equalize the twist by drawing the thread back and forth over the nail or hook.

8. Wrap the thread two or three times around the first two fingers to protect the tapered ends.

9. Wax the entire thread by a brisk backward and forward movement of the wax pad.

10. Work the wax into the thread by a brisk rubbing with the thumb and index finger.

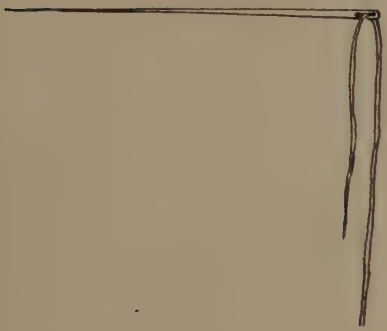


FIG. 55
The harness needle and thread.

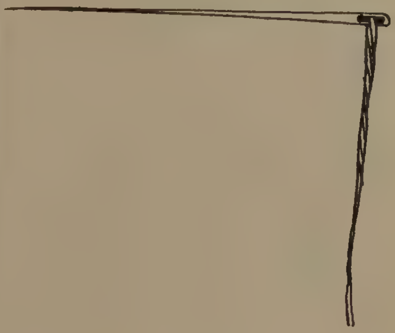


FIG. 56
The needle and thread ready for sewing.

11. Thread the needles with the tapered ends of the threads as in Figure 55, and twist each end back into the body of the thread as in Figure 56.

12. Wax the thread with beeswax. The entire thread should then be rubbed briskly with the thumb and index finger.

JOB 30

TO MAKE A STITCHED SPLICE

Material and equipment.

Sharp pocket-knife or jack-plane or round knife; awl and haft; stitching clamp; harness thread; ruler; pricking and finishing wheel if desired; straps to be spliced.

Procedure.

1. Cut the ends of the straps off square.

2. Bevel the flesh side of the straps to be spliced as in Figure 57, by means of a pocket-knife, a jack-plane or a round knife.

3. Lay the ends of the beveled straps one on the other, hair side up.

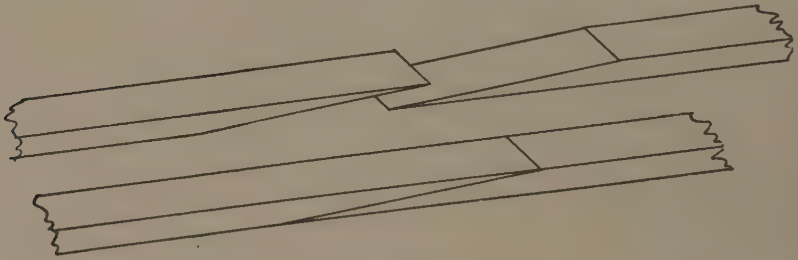


FIG. 57
Cutting the bevel.

4. Mark off with the ruler or the pricking wheel the places for the stitches.

5. Place the straps in the clamp, the hair side of both to your right, lapping the straps two to three inches, depending on the bevel.

6. Make a hole in the left strap just beyond the splice, as in Figure 58.

7. Push one needle through and draw the thread through half-way.

8. Run the awl through the overlapping straps at the next mark nearest you, holding one needle in the left hand and the other needle and the awl in the right, as shown in Figure 59.

9. Push both needles through the hole at the same time, one from either side.

10. Draw the threads through for a few inches; then seize the thread with the hands and draw it tight.

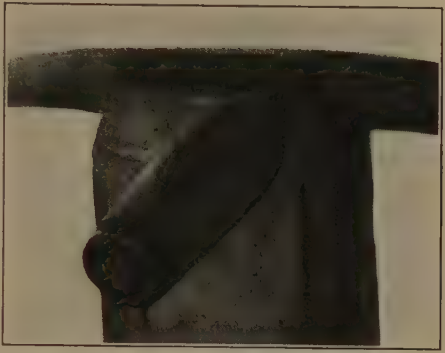


FIG. 58
The use of the awl.

11. Continue stitching in this manner until the last stitch in the two straps is finished.

12. Make one more hole beyond the splice. Push the right needle through and draw the thread tight.

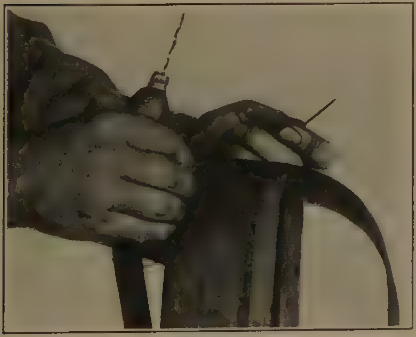


FIG. 59
Sewing the leather splice.

13. Turn the strap end for end and place the other edge up in the clamp. Make another hole just beyond the overlapping straps. Cross the threads on the flesh side and bring one back through to the hair side of the splice.

14. Continue the stitiching one hole beyond the lap. The stitching is finished by putting both needles in the last hole, then winding the thread once or twice around the needle on the right. Then draw both threads tight.

15. If a finishing wheel is at hand, run it over the stitches to improve the appearance.

JOB 31

TO ATTACH A SNAP WITH A CONWAY LOOP

Material and equipment.

Strap ¼″ wide any length; Conway loop; revolving leather punch.

General information.

Conway loops are often used in the repair and construction of the tie straps and reins.

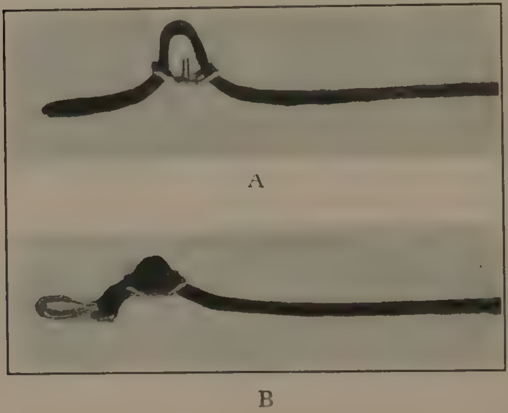


FIG. 60

Attaching a snap preparatory to fitting the buckle.

Procedure.

1. Punch a hole large enough to admit the tongue of the Conway loop in the center of the strap about one-half inch from the squared end.

2. About five inches from this hole, punch another of the same size.

3. Place the strap through the two branches of the Conway loop as shown in Figure 60A, the short end of the strap going through the loop of the snap.

4. In Figure 60B, the strap is in place ready to be drawn tight.

5. Draw the strap tight to complete the job.

JOB 32

TO ATTACH A BUCKLE TO A STRAP BY MEANS OF RIVETS, AS IN THE CONSTRUCTION OF A HAME STRAP

Material and equipment.

Tubular rivets; riveting machine; leather punch; pocket-knife; leather loops; plain buckle; leather strap ¾″ wide.

Procedure.

1. Square one end of the strap and bevel it slightly for a distance of one inch.
2. Double three inches of the beveled end back on itself, flesh side in.

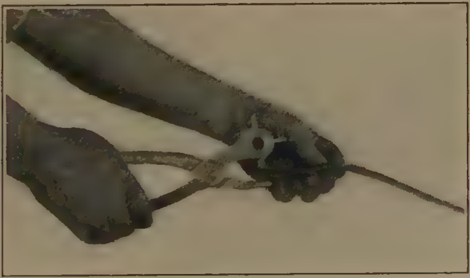


FIG. 61
The use of the leather punch.

3. Punch a hole in the doubled strap one-half inch from the end, sufficiently large to allow free movement of the tongue of the buckle, as in Figure 61.

4. Cut out the section between the two holes just punched, as in Figure 62.

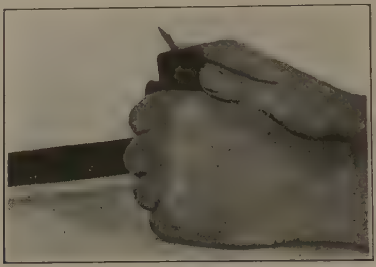


FIG. 62

Cutting the strap preparatory to fitting the buckle.

5. Put the beveled end through a loop, then place the buckle in position and insert the beveled end of the strap through another loop as shown in Figure 63.

6. Put a rivet on each side of the last loop.

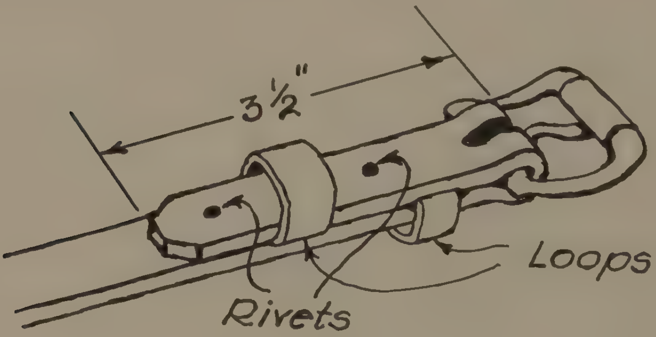


FIG. 63

The buckle attached.

JOB 33

TO MAKE REPAIRS WITH CONCORD OR HAME CLIPS

Material and equipment.

Old tug; file brace; rivets; light hammer; Concord clip; cock-eye; heavy piece of flat iron or anvil.

Procedure.

1. Square the end of the trace and do any stitching that is necessary.

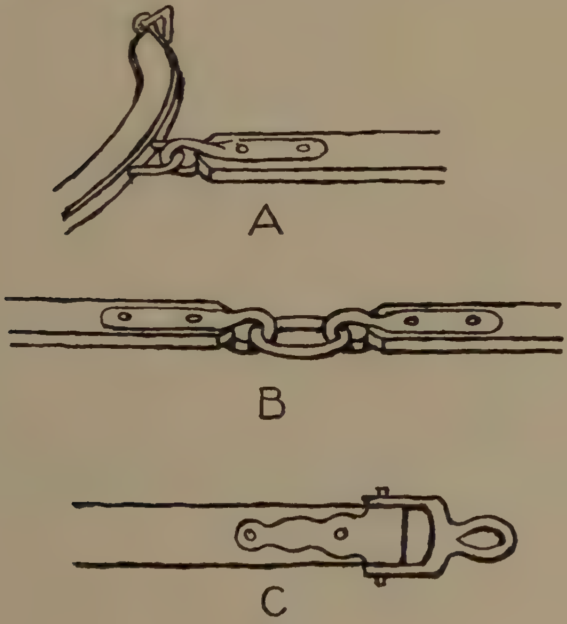


FIG. 64

(A) Hame repair.
(B) Trace repair with two hame clips and link.
(C) Tug repair.

2. Place the cockeye on the clip and insert the trace as shown in A, Figure 64. Allow enough space so that the cockeye will swing freely.

3. Mark the places for the rivets.

4. The holes may be punched or drilled by means of an ordinary brace and saw file, the end of the file being placed in the chuck and the tang used to drill the hole.

5. Assemble the clip, cockeye, and tug. See that everything fits snugly.

6. Insert a rivet. Place the head on the anvil or some other solid metal object and rivet the end. Finish one rivet before proceeding to insert the next one.

7. B, Figure 64, represents a method of repairing a tug with two hame clips and a link.

8. C, Figure 64, shows how to fasten a tug to a hame staple by means of a hame clip.

JOB 34

TO CLEAN AND OIL A HARNESS

Material and equipment.

Wash-tub; board 2″ x 12″ x 6″ with strips along the edges to cause the water to drain back into the tub; scrub brush; sal-soda.

General information.

Proper treatment greatly prolongs the life of a harness.

Procedure.

1. Take the harness apart and make the necessary repairs.

2. If the harness is dirty, put the parts in a tub about half full of warm water in which one-fourth pound of sal-soda has been dissolved.

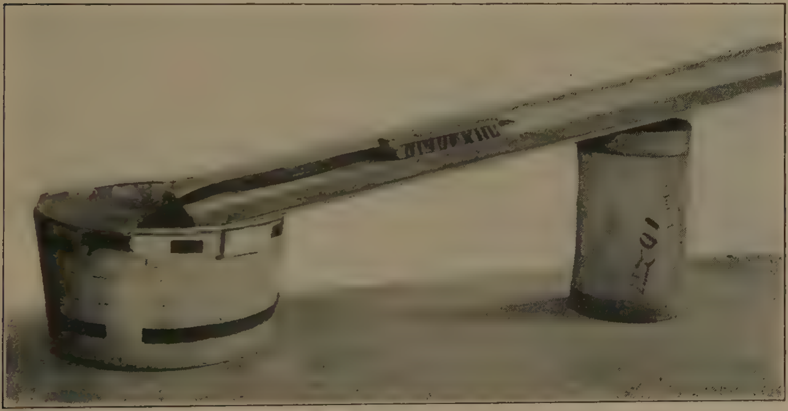


FIG. 65
Equipment for washing harness.

3. After the parts have become well soaked, scrub each piece clean on the drain board and lay it aside to dry. See Figure 65.

4. When the pieces are about half dry, apply harness oil to each piece with a cloth, rubbing it in well.

5. Put the pieces in a pile in a warm room and allow the oil to soak in.

6. The number of applications of oil will depend on the condition of the harness.

7. After the parts have absorbed sufficient oil, wipe them thoroughly and assemble the harness.

References.

Roehl, L. M., *Harness Repairing,* Bruce Publishing Co., 1921.

JOB 35

TO CONSTRUCT A SEWING CLAMP

Material and equipment.

Oak wood (dressed stock); leather; plane; file; brace and bit; saw; square; flat-headed brads; work-bench with vise attached.

Although hardwood is the best kind of material to use for a piece of work of this type, softwood may be used, but it should be of heavier dimensions because of the strength required. If hardwood is used for the little blocks, these should be fastened with small screws with holes drilled in the pieces for fastening. It is well to have the leather hinge long enough to bend over and secure to the sides of the two uprights, as merely tacking into the ends of the boards is not very permanent, especially in softwood.

Procedure.

1. Prepare two pieces of stock planed to 4″ x 14″ from oak wood at least seven-eighths inch thick, using a plane to finish to accurate dimensions.

2. Cut out slots 2″ x 4″ centrally at one end of each piece. This is done by sawing to a depth of four inches on the one-inch lines, and then boring with an auger bit about three-fourths inch in size in one of the corners of the slots. The cross-grain sawing is done from these holes with a compass saw.

3. The top ends of both of these uprights are to be tapered or chamfered to a distance one and one-half inches from the top, still leaving the extreme part of the end one-eighth inch in thickness. Make the taper by holding in a vise and shaving off with a plane.

4. Fasten two ⅞″ x 1½″ blocks to one of the uprights, as shown in Figure 70. If softwood blocks are used, small brads may be driven without danger of splitting. Care must be taken not to use too heavy nails, both here and in tacking the leather.

5. Fasten the leather hinges to hold both pieces together, having cut the leather strips one inch wide and about six and one-half inches long. Use seven-eighths inch flat-headed brads or long tacks for fastening. See Figure 66.

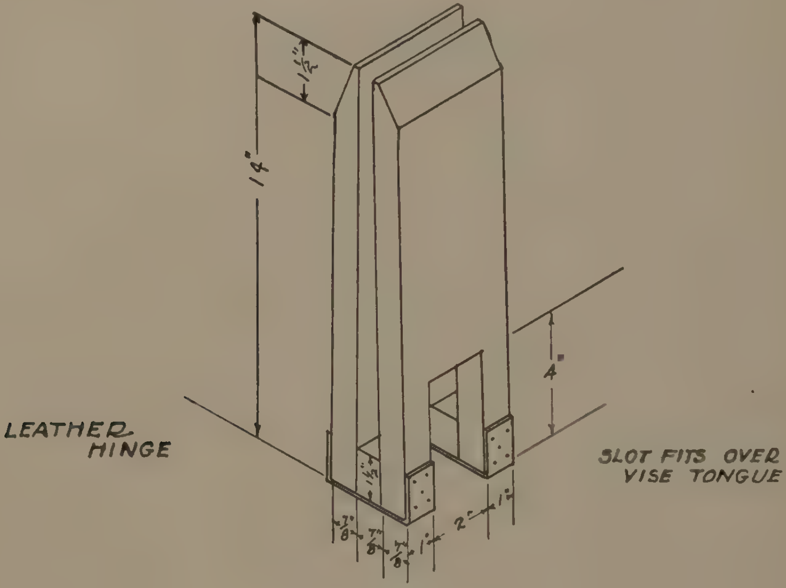


FIG. 66
Harness sewing clamp.

CHAPTER VII

BELTS AND LACES

There are three general classes of belts: rubber, canvas or Gandy, and leather belts.

Rubber belts are manufactured by vulcanizing several thicknesses of canvas together. The splice is indicated by a colored strip on one side of the belt. Always run this splice opposite the pulley. The ply of a rubber belt is shown by the number of thicknesses of canvas visible on the freshly cut end. Rubber belting is very serviceable and popular because of its flexibility and its excellent pulley grip, and because it will withstand weather conditions. In preparing a rubber belt for lacing, do not make the holes very large, as the belt will be much weakened by having the warp threads cut. Rosin dressing, tar, or any mineral oil should not be used on rubber belts. A few drops of castor oil applied sparingly makes a very satisfactory dressing.

Canvas or Gandy belts are made by stitching several thicknesses of canvas together. The ply is indicated as it is in a rubber belt. When a canvas belt is being broken in, steam cylinder oil, when applied in very small quantities to the pulley side while it is in motion, will make the belt much more flexible, causing it to grip the pulleys better. Canvas belts are used largely for drive belts on the various farm power machines. After the season is over, the belt should be washed thoroughly with warm water, naphtha soap, and a scrub brush to remove all traces of grease and dirt, after which it should be laid in the sun to dry. After it has become thoroughly dry, it should be painted with a mixture of raw linseed oil and red ochre. Roll the belt up and lay it flat where mice can not injure it during the winter months.

Leather belts are made by gluing strips of leather together. The smooth side of a leather belt is known as the "hair side" and should always be run next to the pulley because the smooth surface grips the pulley better and does not stretch as easily as the flesh side. Leather belts should not be exposed to water, mineral oil, or heat. Neat's-foot oil makes a very satisfactory dressing if applied in small quantities.

In *belting pulleys* the tight side of the belt should be below in order to increase the area of contact of the belt with the pulleys. Any idler pulley should be fairly near the drive pulley and should bear against the slack side of the belt. It is usually inadvisable to use a pulley with a flanged edge, but if that is unavoidable, give it plenty of clearance.

Every machine should be properly lined up in the belt. The three factors to consider in lining a machine up for belt work are: (1) that both machines are squarely in line; (2) that three points are in line, that is, the center of the drive pulley, the center of the driven pulley, and some other point on the frame; (3) that it has been decided whether to use a straight or twisted belt.

JOB 36

TO MAKE THE LIGHT AND HEAVY DOUBLE BUTT LACE WITH A LEATHER THONG

Material and equipment.

Leather lacing thong; belt ends; awl; leather punch.

Procedure.

1. Note the system of punching the holes in each method of lacing.

2. Insert the lace ends in the center holes from the hair side of the belt and draw them through equally.

3. Cross the end of the upper lace to the hole at the left of the center and bring it up through from the flesh side, as in A, Figure 67.

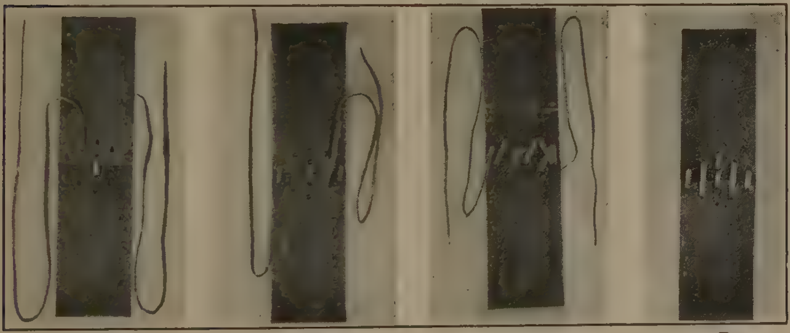


FIG. 67
The double butt lace.

4. Make all laces straight on the hair side and do all crossing of laces on the flesh side of the belt. Continue the lacing on both sides of the center.

5. When the side is reached, proceed to double the lace. B, Figure 67, shows the hair side of the belt at this stage; and C, Figure 67, the flesh side.

6. After both ends have been laced back to the center, run them through the tie holes. The center lace is single and those on each side of the center are double.

7. D, Figure 67, shows the completed lace.

JOB 37

TO MAKE A HINGE LACE WITH A PROTECTING LACE, USING A LEATHER THONG

Material and equipment.

Leather lacing thong; belt ends; awl; punch.

General information.

This lace is very flexible and will outwear any other leather-thong lacé made.

Procedure.

1. Note the system of punching the holes.

2. Run one end of the lace through the upper belt end and draw it through half-way.

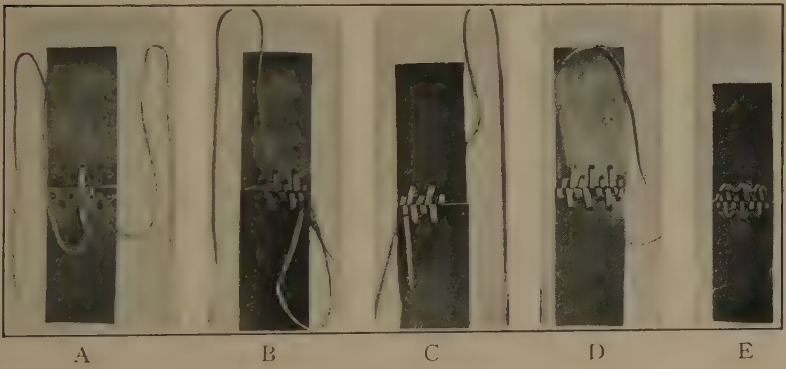


FIG. 68

The hinge lace with protecting lace.

3. Run the end coming out on top of the upper belt under and up through the lower belt from the flesh side. The lower lace from the upper belt is brought up and run down through the lower belt from the hair side, as shown in A, Figure 68.

4. Lace to the edge on one side. In B, Figure 68, the lace coming from the upper belt has been inserted in the outer right hole of the lower belt. C, Figure 68, shows the flesh side of the belt at the same stage, the thong being pulled through tightly.

5. Draw the thong through tightly.

6. Complete the other half of the lace as shown in D, Figure 68.

7. Note that there are no cross-overs in this lace. It resembles a baseball stitch. If the lace has been correctly made, there will be one V on each side of the belt on opposite edges.

8. Lace the end of the thong across the belt and back to complete the protecting lace as shown in E, Figure 68. Do not allow the lace thong to become twisted.

9. Cut the surplus thong off on the flesh side.

10. Make a slanting cut in the thong to prevent its slipping back through the hole.

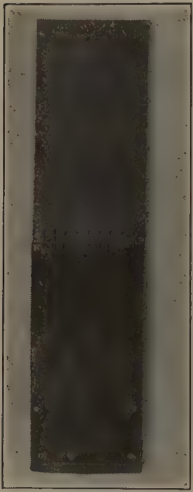


FIG. 69
The wire lace.

In Figures 69 and 70 are shown two methods of metal lacing. The wire lace in Figure 69 is made similarly to the light double butt lace, using lacing wire instead of the leather thong. After the lacing is completed, the wire is pounded down or buried in the leather just flush with the surface. Figure 70 is self-explanatory.

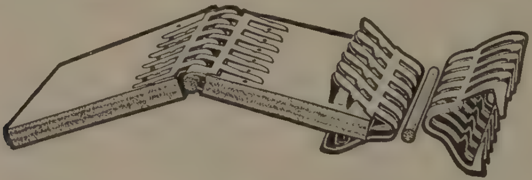


FIG. 70
The alligator steel belt lacing. (Courtesy Flexible Steel Lacing Company.)

References.

Short Cuts to Power Transmission, Flexible Steel Lacing Co., Chicago, Illinois, 1922.

CHAPTER VIII

FARM-TOOL CARE AND REPAIR

SELECTION AND CARE OF TOOLS

In selecting tools and equipment for the farm shop, one should be governed by a survey of the various types of work that may be encountered. Select those tools which are necessary for doing jobs which are to be done on the individual farm. Purchase only tools of high quality and of standard make.

The prime *prerequisite in the care of tools* is: a definite place for every tool and every tool in its place. This will increase the efficiency of the individual and will result also in a big saving because of decrease in the depreciation and elimination of the loss of tools. Tools must not be left exposed to the elements or stored away wet, since, if this is done, they will rust rapidly, the handles will check and warp, and decay will set in quickly. Every self-respecting mechanic keeps his tools in good condition and does not abuse them.

Keen-edged tools, such as plane bits, files, chisels, and bearing scrapers, should not be knocked or thrown against other tools or hard substances, but should be handled with respect.

All *polished surfaces of tools* should be wiped with an oily cloth occasionally to prevent rust. Ordinary machine oil is satisfactory for this purpose. Rust may be removed by soaking the surface in kerosene for twenty-four hours and then polishing it with a fine emery-cloth and light oil.

GRINDING EDGED TOOLS

Certain fundamentals should be observed in the sharpening of edged tools. The emery-wheel or grindstone always should be run toward or against the cutting edge of the tool. If the grinding wheel is rotated in this direction, the cutting edge is reinforced by the body of the tool, and a keener edge can be secured. If the grinding wheel is rotated away from the cutting edge, there will be a tendency to tear small particles away, a ragged cutting edge resulting.

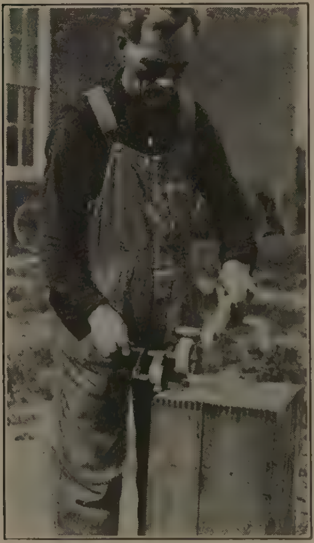


FIG. 71
Tool for dressing down an emery stone.

Always move the tool back and forth across the face of the wheel to insure an even wear on both.

Be very careful to remove the tool from the emery-wheel before it gets hot enough to destroy the temper of the tool.

It is wise to have a container of water nearby or fastened to the emery-wheel stand. The tool may be dipped in this at short intervals in order to keep it cool when being ground.

To be of the best service, any grinding wheel should be kept dressed down uniformly. An emery-wheel which has become uneven and needs dressing down may be smoothed down by use of the home-made dressing tool shown in Figure 71.

It is constructed by filling a one-half inch bolt, six or eight inches long, with washers. When the stone is turned against the washers, the play of the washers grinds down the higher parts, and by a gradual adjustment of the dressing tool closer to the stone, it is made true again.

Run the power-driven emery-wheel at the proper speed. See Table 6 in the Appendix, page 382.

JOB 38

TO SHARPEN A TWIST-DRILL*

Material and equipment.

Emery-wheel grinder, power or hand operated; grindstone; twist-drill.

Procedure.

1. Grasp the shank of the drill firmly in the right hand. Place the back of the index finger on the rest and let the drill lie in the crease of the first joint, as shown in Figure 72. The central axis of the drill is held at an angle of 60° to the face of the wheel.

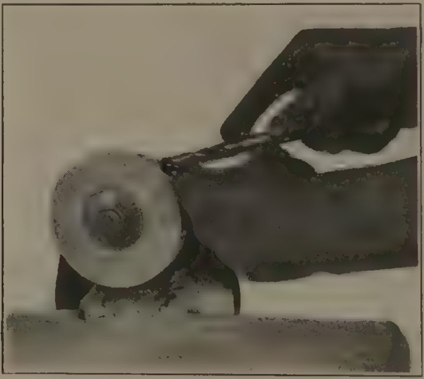


FIG. 72
Grinding the twist-drill.

2. Press the cutting edge against the face of the grinding wheel. With each stroke of the drill on the grinding wheel, lower the shank and at the same time slightly rotate the drill clockwise.

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* See Appendix, p. 381 for table of twist-drill speeds for average repair work.

3. A properly ground drill will have a regular curved surface from the cutting edge to the trailing edge. In Figure 73 you will note the necessary angle of clearance.

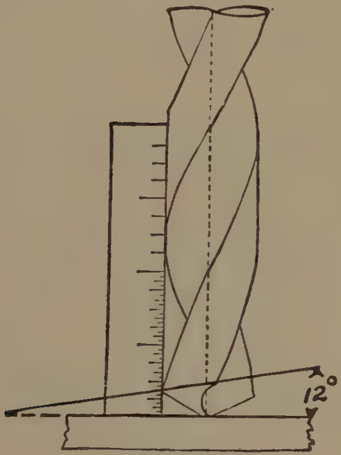


FIG. 73
The angle of clearance of a correctly sharpened twist-drill. (Courtesy Morse Drill and Machine Company.)

JOB 39

TO SHARPEN A WOOD CHISEL

Material and equipment.

Emery-wheel grinder; wood chisel.

Procedure.

1. Grasp the chisel firmly in the right hand, laying the fingers of the left across it near the cutting edge. Let the back part of the bevel come in contact with the wheel. Gradually raise the handle end until the correct angle of contact, which should be about 30° for average conditions, is obtained, as shown in Figure 74.

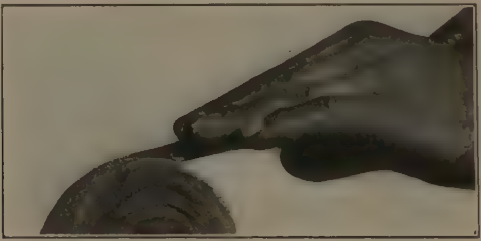


FIG. 74
Correct angle of contact for sharpening a wood chisel.

2. Continue the grinding until a slight feather edge is turned up on the back.

3. Whet the chisel on the oilstone as shown in Figure 75. The heel of the concave bevel is raised slightly from the face of the stone. This slight bevel should be maintained constantly. It is best to use a rotary movement, working over the entire face of the

stone. Continue whetting until a very slight feather edge is turned back.

4. Lay the chisel flat on the stone, bevel up, and give it a few strokes to remove the wire edge.

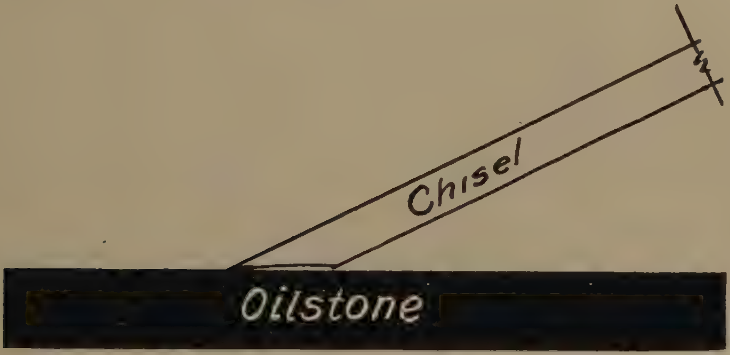


FIG. 75

Note hollow-ground chisel and the short bevel when finishing on the oilstone.

JOB 40

TO SHARPEN A MOWER SICKLE

Material and equipment.

Grindstone; mower sickle.

Procedure.

1. Grasp the blade firmly and hold it on the stone as in Figure 76. Begin at either end.

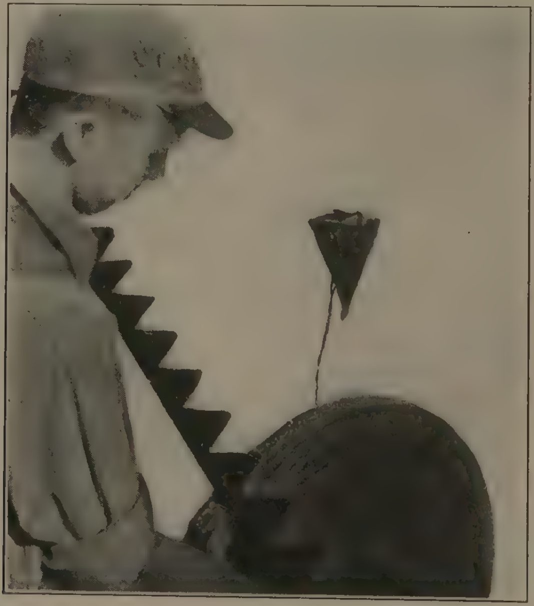


FIG. 76

Sharpening the mower sickle.

2. Rotate the stone toward or against the cutting edge.
3. Observe the results of the grinding often at first until you

determine the proper angle of the section to the face of the stone. Hold the blade steadily and in the same relative position to secure the same bevel on each section.

4. Test the keenness of the cutting edge of each section by touching it lightly with the end of the finger before passing to the next section.

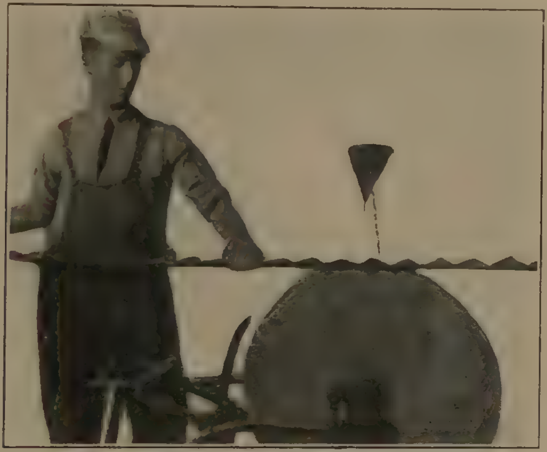


FIG. 77
Removing the wire edge.

5. Grind one edge of each section the entire length of the blade; then hold the blade at the same angle on the other side of the stone and grind the remaining edges.

6. After all edges have been ground, lay the blade flat on the stone as in Figure 77. Rotate the stone and draw the blade slowly along to remove any wire edges that may have been turned up.

JOB 41

TO HANG A FORK

Material and equipment.

Fork; ferrule; fork handle; wood rasp; twist-drills; brace, hammer; spoke-shave; vise.

General information.

In selecting a handle for any tool, choose a clear white wood having a fine grain running the full length of the handle. The life of a tool handle may be lengthened by applying boiled linseed oil and allowing it to soak in thoroughly. This prevents the evaporation of moisture. It is much more economical to purchase the handles needed at the hardware store than to turn them out yourself.

Procedure.

1. Remove the old fork by striking it first on one side and then on the other.
2. Remove the ferrule from the old handle.
3. Fit the ferrule on the new handle, being careful to place the slot in the end in the proper position. Work the handle down with the wood rasp if necessary.
4. Insert the fork tang in the handle as follows:
    a. Note that the width of the fork is at right angles to the curve of the handle.

    b. It may be necessary to enlarge the hole slightly with a twist-drill. The hole should be one-half inch shorter than the length of the tang.

    c. The fork may be driven on by striking between the tines at the base with the peen of a cross-peen hammer, or by holding a piece of flat bar iron between the tines and striking it with the hammer.

    d. Sight down the handle often to note if the tang is going in true.

JOB 42

TO HANG AN AX

Material and equipment.

Ax; handle; wood rasp; twist-drills; brace; hammer; spoke-shave; vise.

Procedure.

1. Remove the old handle by driving it out with a large punch, or, if that is impossible, drill part of it out with a twist-drill. The remaining material may be driven out easily.

2. Try the ax on the new handle to note where the handle must be taken down. Reduce the eye stock by means of the wood rasp or spoke-shave. Note that the ax may be swung in the opposite direction from where the stock is removed.

3. Fit the ax well up against the base of the eye stock.

4. If no metal wedges are on hand, use wood. Split the eye stock lengthwise and drive in a wedge of the same width.

5. Saw the surplus eye stock off three-fourths inch from the ax and, after splitting the stock, drive in two wedges crosswise to the eye.

6. Saw the stock off nearly flush with the ax eye and dress it down with the rasp.

Hand-saws are of two general classes.

The *rip-saw* is used in cutting with the grain of the wood. The teeth of the rip-saw act as a series of chisels. The comparatively broad, sharp edge separates the fibres of the wood lengthwise with the grain and does not cut on the sides. The saw in being pushed forward tears the fibres away from the wood at the sides.

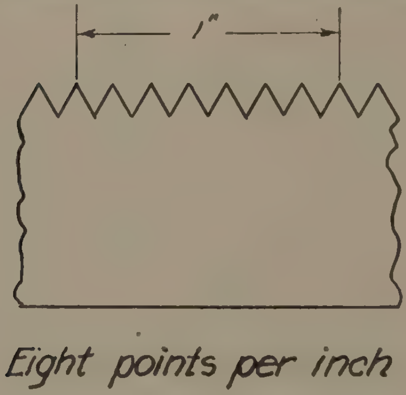


FIG. 78
Diagram of a saw.

The *cross-cut saw* has more the action of a knife and chisel combined. The first pressure on the points of the teeth of a cross-cut saw cuts the surface fibres at the extreme points of the saw teeth. Following pressure cuts the fibres and chisels them out.

Saws are also designated by the number of points. For example, in Figure 78 there are eight points per inch or seven teeth; therefore, a saw with such a blade would be called an "eight-point saw." The number of points is usually stamped on the blade. For general use, a twenty-six inch, seven-point saw is recommended.

Saws vary according to the work for which they are intended. In general, the softer the material to be sawed, the greater will be the length of the tooth required, the wider the set, the greater the rake. By *rake* is meant the slant of the tooth. *Setting* consists in bending alternate teeth in opposite directions.

Gumming consists in deepening the gullet by filing or grinding.

Jointing is the process of filing all teeth to the same height.

In Figure 79 you will note the different parts of a hand-saw. The breast should be slightly crowning. A good saw should be springy and elastic and should curve evenly from point to handle when it is bent.

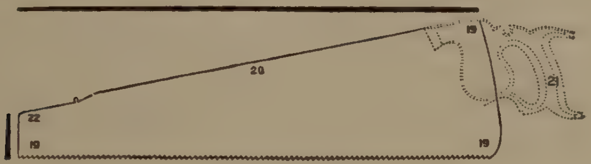


FIG. 79

Parts of a hand-saw. (Courtesy Henry Disston and Sons.)
No. 19 is the "breast"
No. 20 is the "back"
No. 21 is the "handle"
No. 22 is the "point"

JOB 43

TO FIT A HAND CROSS-CUT SAW

Material and equipment.

Six-inch slim-taper file; 12″ mill file; 12″ round-back file; saw-set; saw clamp; emery-cloth; emery dust; thin oil; pumice-stone.

Procedure.

1. Remove the handle and place the blade on a flat surface.
2. Apply a light oil to the blade and rub it briskly with the emery-cloth. If the cloth loses its abrasive properties, apply a small amount of emery dust to the blade.
3. Clean both sides of the blade. If a bright polish is desired, finish with pumice-stone and water and a cloth.
4. Place the blade in the saw clamp as in Figure 80.
5. To joint the saw, grasp the file solidly, as shown in Figure 80, and run it forward over the teeth until the teeth are all of an even height and the breast is slightly crowning. Figure 81.
6. Place the saw down in the clamp, the breast protruding just enough to allow for filing. If the teeth are of an uneven size or nearly jointed away, cut them to an equal size by filing straight across the blade.
7. Raise the saw in the clamp about four inches.
8. Adjust the saw-set to correspond to the number of points per inch on the blade and so that it will fit snugly against the blade

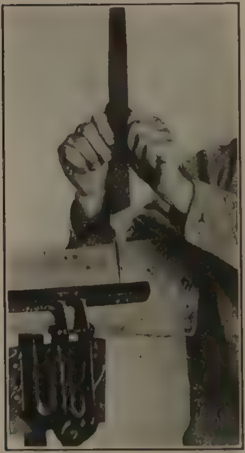


FIG. 80

Position of the saw blade in the clamp.

to insure an even set of all teeth. The bevel side of each tooth should be bent away. Set every other tooth from one side, then reverse the saw in the clamp and set the remaining teeth.

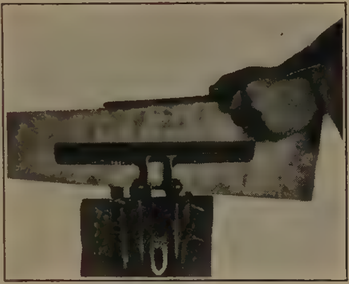


FIG. 81
Jointing the saw.

9. For average farm work, file a 45° bevel on the teeth by holding the file at a 45° angle to the length of the blade, as shown in Figure 82. Keep the file practically level and file the face of all teeth set away from you, that is, file every other tooth. In the beginning, file a short distance, then reverse the saw in the clamp and file the remaining parts of the tooth, constantly keep the original relation of the file to the length of the blade 45°. After becoming accustomed to the proper amount to file each tooth, continue the length of the blade before changing the position of the blade in the clamp. Every tooth should be brought to a sharp point.

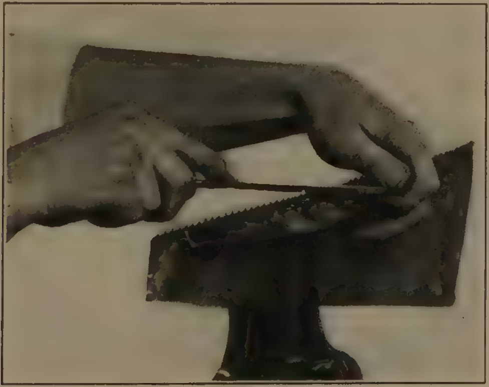


FIG. 82
Filing the saw.

10. After the saw has been properly filed, side joint it by laying the blade on a flat surface and passing a partly worn-out file or abrasive stone along the side of the teeth, as shown in Figure 83. Side joint both sides of the blade.

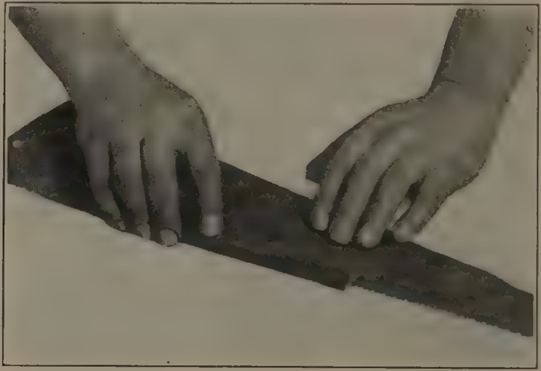


FIG. 83
Side jointing the saw.

11. Assemble the saw and test it out thoroughly before taking it from the shop. If the set is uniform, but the saw runs to one side, it is an indication that the teeth on one side are longer than on the other side, a result of improper filing.

JOB 44

FITTING A HAND RIP-SAW AND A CROSS-CUT TIMBER SAW

Material and equipment.

Six-inch slim-taper file; 12″ mill file; 12″ round-back file; saw-set; saw clamp; emery-cloth; emery dust; thin oil; pumice-stone.

A. Hand Rip-Saw

Procedure.

1. Proceed the same as in filing a hand cross-cut saw, but with these exceptions:

a. File the teeth straight across the blade, the face of all teeth being straight up and down or slanting slightly forward.

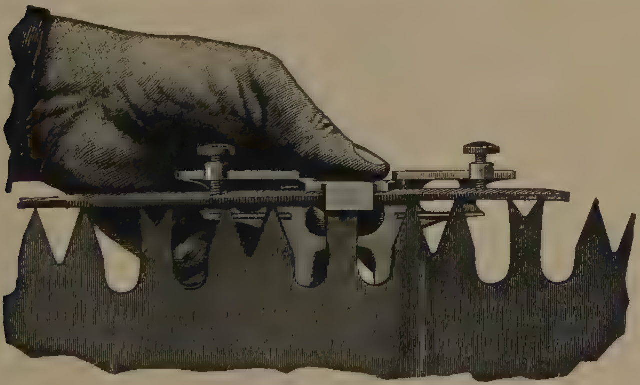


FIG. 84

Jointing the hand cross-cut saw. (Courtesy Simonds Saw Company.)

b. File the back of every other tooth, then reverse the position of the saw in the clamp and file the remaining teeth. This last step is taken to equalize any mistakes which may habitually be made, and causes the saw to run straight.

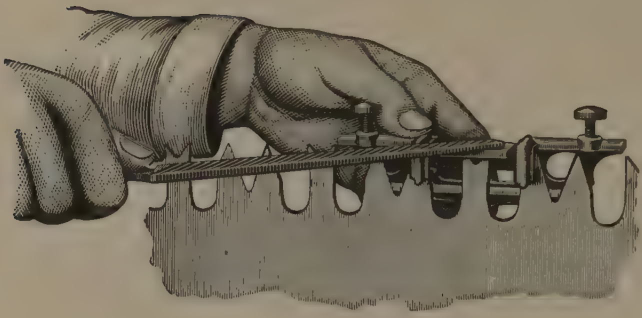


FIG. 85
The saw tool in position over a raker. (Courtesy Simonds Saw Company.)

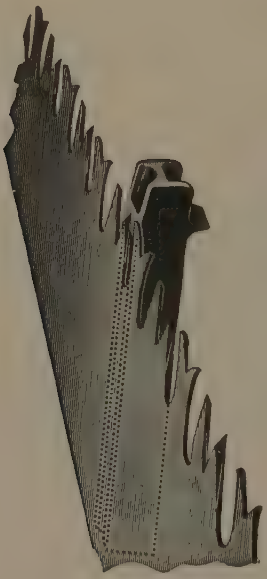


FIG. 86
Setting the cross-cut timber saw. (Courtesy Simonds Saw Company.)

B. Cross-Cut Timber Saw

Procedure.

1. Joint the saw by placing the mill file in the saw tool as shown in Figure 84. Holding the file on the teeth and the tool tightly against the blade, run the file forward over the teeth until all have been touched.

2. If the gullets have become shallow, they should be gummed out. This can be accomplished by filing them at right angles to the length of the blade with the round back file. File the gullets to a uniform depth.

3. Place the saw tool over a pair of rakers as shown in Figure 85. The rakers should be one sixty-fourth to one thirty-second inch shorter than the teeth. Adjust the tool accordingly and file off the protruding parts.

4. Set one-fourth inch of the point of each tooth as shown in Figure 86. Set the alternate teeth in opposite directions.

5. File the rakers straight across and to a chisel point.

6. File both sides of a tooth projecting away from you before passing to the next one. Be very careful not to file either teeth or rakers below their proper levels.

CHAPTER IX

MISCELLANEOUS JOBS FUNDAMENTAL IN FARM CONSTRUCTION AND REPAIR

USE OF METAL-WORKING TOOLS

A. Files

Filing is an art acquired only by patient, intelligent practice. In using a file, one should assume an easy natural position. In cross filing, grasp the file as shown in Figure 87. Take full, regular strokes, using the full length of the file. Because of the peculiar shape of a file tooth, it will stand a great pressure against the face and but little against the back. Therefore apply a steady pressure on the forward stroke but on the return stroke raise the file and draw it back without touching the metal. The file is quickly dulled if it rubs the metal on the return stroke. The tendency of the beginner is to rock the file; thereby causing the center of the work to be high. Always attempt to keep the file perfectly level. After the surfaces have been filed fairly accurately by cross filing, one may secure a smoother and more perfect job by draw filing. Grasp the file firmly by both ends and move it for-

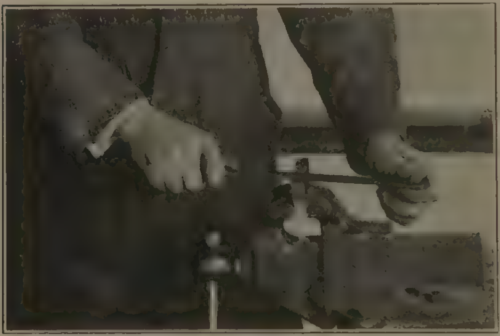


FIG. 87
Cross filing.

ward and backward with equal pressure as shown in Figure 88. The cutting is done on both strokes.

Figure 89 shows the different classes of cuts used in the manufacture of files. There are a number of different grades of each cut, depending upon the kind of work for which the file is intended.

Figure 90 shows the different kinds of files with which one should be familiar. Their uses are as follows:

1. *Tapered saw files* are used principally for filing saws; the taper may be regular, slim, or extra slim. The length of all files is designated by inches of the cutting surface. They are single cut.

2. *Round files* are used for gulleting and enlarging holes. They are usually tapered and double cut.

3. *Half-round files* are used for rounding out surfaces and for filing flat surfaces. They are usually tapered and are double cut.

4. *Mill files* are used for filing timber cross-cut saws; for jointing saws, finishing work after the flat bastard has been used; and for draw filing. They are single cut.

5. *Flat files* are used for taking off the rough parts of forgings and other rough work; they are usually bastard, double cut.

6. *Rasp files* are usually used for woodworking. They are coarse and cut very rapidly.

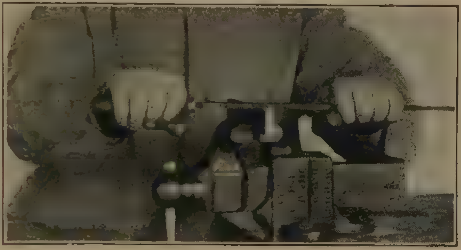


FIG. 88
Draw filing.

B. Taps and Dies

A complete set of taps and dies, as shown in Figure 91, is known as a screw plate. Taps and dies are very closely related. The tap cuts an internal thread in the nut or fitting, while the die cuts the companion thread on the bolt or pipe. They may be divided into two classes: pipe and bolt. They differ not only in the number of threads cut per inch, but also in actual size. For example, a one-half inch United States Standard tap is made to cut a thread for a one-half inch bolt in a seven-sixteenths inch drilled hole, while a one-half inch pipe tap is made to cut a thread for a one-half inch pipe, the outside measurement of which is three-fourths inch, in an eleven-sixteenths inch hole. In other words, pipe measurements are taken inside, while bolt measurements are taken outside.

Taps and dies are usually marked with the number of threads per inch, the size, and the direction of the thread (right-hand or left-hand). The better classes of dies are adjustable. Solid dies are not adjustable, and when worn will not cut the threads deep enough. Should one cutting lip become broken, the die would be ruined, while in the case of an adjustable die, the lip could be replaced at a slight expense.

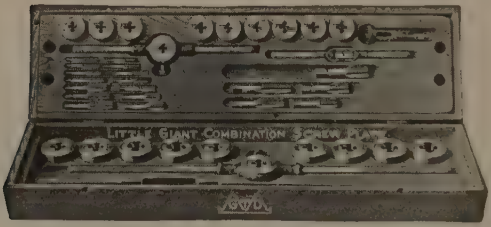


FIG. 91

Screw plate. (Courtesy Greenfield Tap and Die Company.)

Every farmer should be familiar with the different *kinds of threads:*

United States Standard, found mostly in farm machines.

Society of Automobile Engineers, used in automobile construction.

The pipe thread, used in practically all pipe work.

By referring to the table in the Appendix, page 384, the size of tap, tap drill, and number of threads per inch may be determined easily for the different kinds of threads.

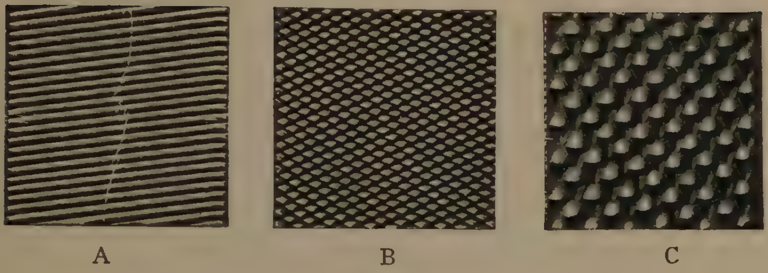


FIG. 89

Classes of files:

(A) Single cut, or chisel-like action. (B) Double cut, or points cutting in parallel. (C) Rasp cut, points staggered and cutting individually. (Courtesy Henry Disston and Son.)

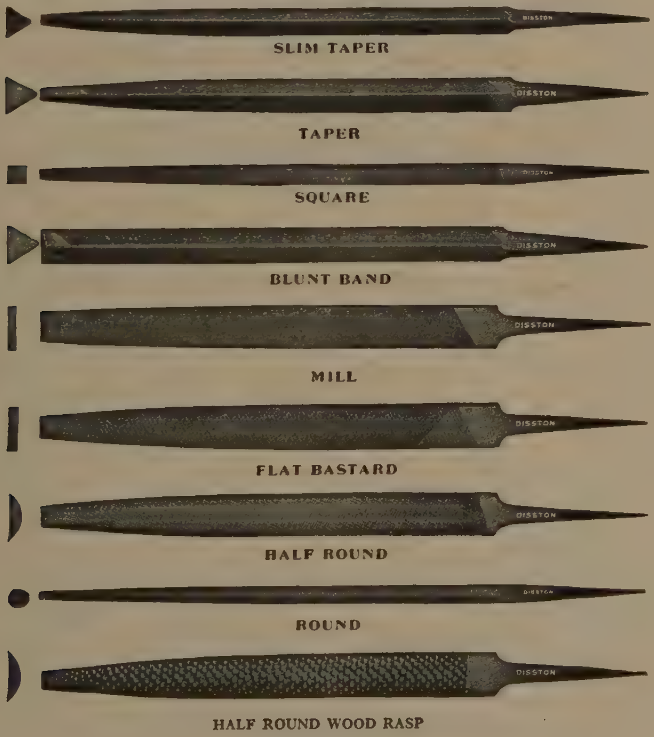


FIG. 90

Kinds of files. (Courtesy Henry Disston and Sons.)

JOB 45

TO MAKE AN EMERGENCY REPAIR BOLT

Material and equipment.

Screw plate; hack-saw; center punch; hammer; blacksmith's or machinist's vise; scratch awl; mill and flat bastard files; drill-press; flat bar iron ½″ x 1″; ½″ round stock.

Procedure.

1. File one end of the flat bar perfectly square.

2. Measure back a distance equal to the width of the bar and with the scratch awl mark off a perfect square.

3. Find the center of this square by drawing diagonal lines. Mark the center plainly with the center punch or cold chisel to prevent the drill from "running", which might result in a bent or broken drill.

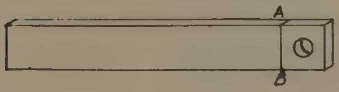


FIG. 92
Diagram of iron bar used in making emergency repair bolt.

FIG. 93
Position of hack-saw in cutting a bar of iron.

4. Select a drill of proper size. Fasten it firmly in the chuck of the drill-press.

5. Place the bar in a solid level position. Lower the drill into place and adjust the feed. When the drill starts to cut, apply lard oil freely.

6. As the drill begins to go through the bar, the feed should be decreased and, in the case of a hand-driven drill-press, the speed

should be greatly increased to prevent the drill from jamming in the hole. The bar should be held *very firmly in place.*

7. Place the bar firmly in the vise and saw it off on the marked line, AB in Figure 92. (You will note that the teeth on the hack-saw blade all slant forward. These blades are made from very hard tempered steel. The same principle applies in the use of a hack-saw as in the use of a file.)

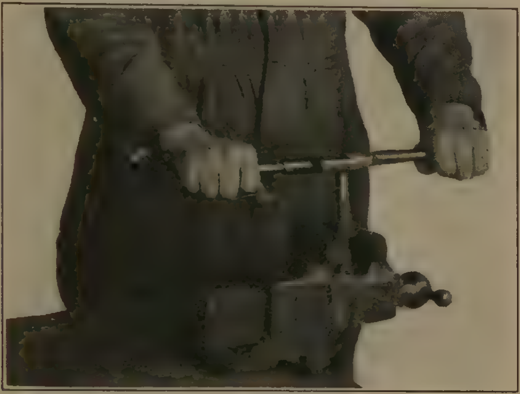


FIG. 94
Tapping the thread in the emergency repair bolt.

8. Grasp the saw firmly as in Figure 93. Use a steady, firm movement and avoid heating the blade.

9. Place the blank nut in the vise and tap the thread as in Figure 94. Grasp the tap-wrench handles firmly and rotate the tap slowly two or three turns until it catches. Be careful to keep the tap at right angles to the face of the blank. If by sighting you find the tap is not started true, reverse it and apply pressure in the required direction on the forward stroke. Keep the tap well oiled with lard oil or

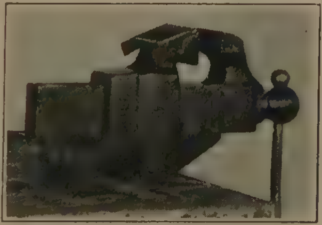


FIG. 95
The jaws of the vise covered with sheet metal.

sperm-oil. (It is best not to use oil when tapping cast-iron as the cuttings tend to stick to the flutes of the tap.)

10. After the thread has been tapped in the blank nut, file it perfectly square by using both the draw filing and cross-filing methods, if necessary. If the jaws of the vise mar the faces and sides of the nut, cover the jaws with sheet metal, as shown in Figure 95.

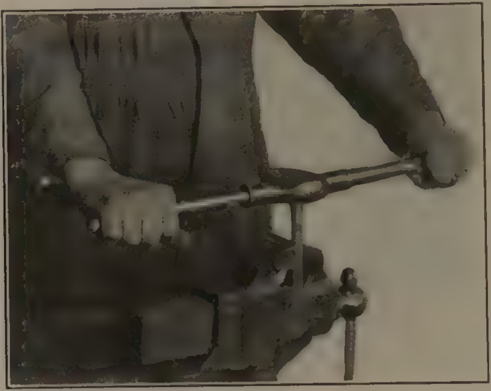


FIG. 96

Cutting the thread for the emergency repair bolt.

11. Cut off eight inches of the round stock. Round off each end by means of the hammer and anvil or by filing.

12. Place the blank firmly in the vise.

13. Select a die of the proper size and fit it in the die-stock.

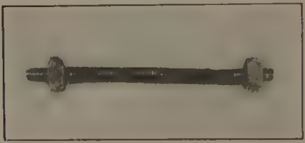


FIG. 97

The completed bolt.

14. Start the die on the bolt as in Figure 96 by a rotating downward movement. As soon as it catches, apply lard oil at short intervals until the thread is cut. It is often advisable to turn the die back a little every few revolutions to facilitate the removal of cuttings and permit the oil to reach the cutting teeth

better. If it is desired to cut a thread close to a shoulder, turn the die over and proceed as before.

15. Cut a thread on the other end of the bolt.
16. See Figure 97 for the finished bolt.

TO MAKE AND FIT THE THREE KEYS, STRAIGHT, FEATHER, AND WOODRUFF, TO A SHAFT AND COLLAR

Material and equipment.

Hack-saw; 12″ mill file and 14″ flat bastard file; machinist's or blacksmith's vise; shaft with keyways and collar to fit; flat bar iron ⅜″ x 1″ x 1′; 1′ round bar iron.

KEY FITTING

General Information.

The shaft illustrated in Figure 98 may be turned out in a lathe. The shaft is two inches in diameter by sixteen inches long and has three keyways one-fourth inch wide. The *straight-key* illustrated on the left is two and one-half inches long. The *feather key* in the center is two inches long. The *Woodruff key* on the right is one-fourth inch at its widest point. The collar is made to fit the shaft with a four-thousandths inch clearance. The straight key is very common in setting pulleys or wheels solidly on shafts or axles. The feather key is not found as often in present-day construction of machinery, although it is sometimes found in transmissions or where there are sliding gears. The Woodruff key is very common and is used for setting pulleys or gears on shafts where the keyway could not extend to the end of the shaft.

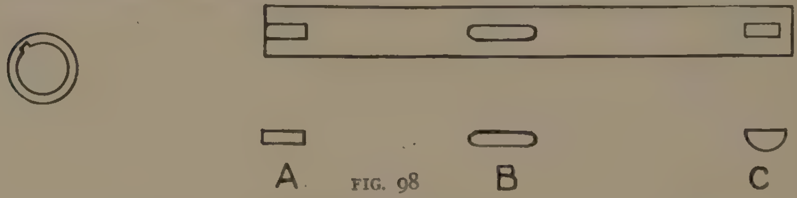


FIG. 98

Diagram of a shaft:
(A) Straight key. (B) Feather key. (C) Woodruff key.

A. Straight Key and Feather Key

Procedure.

1. Saw out a piece of the flat bar large enough to allow for filing it to the proper size and shape.

2. Fit the key to the keyway in the shaft and collar. Examine the blank often to check the results of your filing.

3. File the ends of the feather key so that the entire key fits the keyway snugly.

B. Woodruff Key

Procedure.

1. From the round stock saw a piece sufficiently large to allow plenty of stock for dressing it down to a snug fit.

2. The key should fit snugly clear to the bottom of the keyway in the shaft as well as in the collar.

1. The *round-head rivet* is used in fastening the framework in practically all farm machines, tractors, and automobiles.

2. *Countersunk-head rivets* are employed in riveting metal pieces where clearance is an important factor.

3. *Tinners' rivets* are used in sheet-metal work.

4. *Tubular, copper,* and *slotted rivets,* and *hame staples* are used largely for harness repairing.

5. The *wagon-box head rivets* are used principally in the repair and construction of wood appliances. In all cases where wood is being riveted, the rivet should fit the hole very snugly or there will be danger that the rivet will bend under the hammer blows and split the wood. Only light blows should be used in heading the rivet unless there can be no danger of doing damage to the wood.

6. *Riveting of metals* may be done either hot or cold. By the hot method the rivet is heated red hot, placed in the hole, and quickly cooled. The rivet, being hot, fills the one, and, on cooling, the shrinkage of the rivet draws the metals more tightly together. A well-rounded rivet head is much stronger than a flat one which covers a large area.

JOB 47

TO REPLACE A BROKEN OR WORN-OUT SECTION IN A MOWER SICKLE

Material and equipment.

Ball-peen hammer; mower sickle with section needing replacement; vise; new sections; rivets to fit; punch; anvil or other solid metal base.

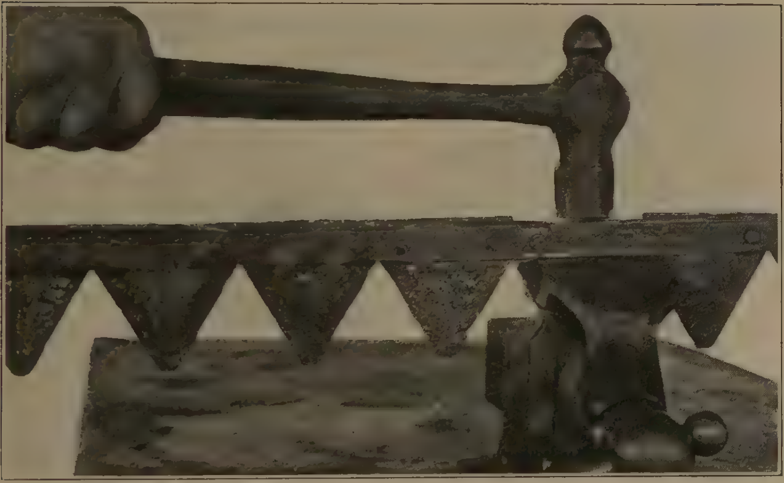


FIG. 99

Removing the section from a mower sickle.

Procedure.

1. Knock out the poor section by placing it loosely in the vise as in Figure 99 and striking a firm blow directly above the rivet. This will shear the rivet off.

2. Remove the rivet stubs by means of the small punch.

3. Put the new section in place and insert the two rivets.

4. Lay the sickle across the anvil. The first blows struck should be squarely on the end of the rivet with the face of the hammer. This will cause the rivet to expand and fill the hole.

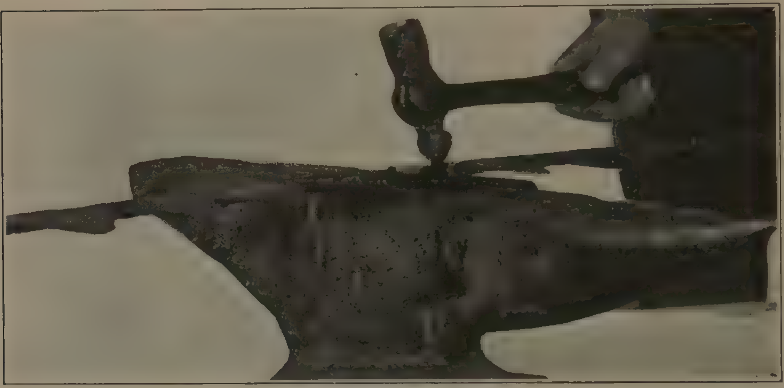


FIG. 100
Round the head of the rivet.

5. Round the rivet head by directing the blows on the edge toward the center as in Figure 100.

6. Finish the other rivet, noting that the section fits down snugly.

7. Sight down the length of the sickle. Remove any crookedness by laying the sickle lengthwise on the face of the anvil and striking on the bar where bent.

CHAPTER X

PIPE FITTING

As a rule, the farmer will not be called upon to do enough pipe fitting to warrant a very great expenditure for pipe-fitting tools. The *principal tools* that he will need are a pipe stock and set of dies or an adjustable die, a sixteen-inch pipe wrench, a single-wheel pipe cutter, a twelve-inch half-round file, a pipe vise, and white lead or thick paint. It is also advisable to have a few of the common fittings and a few feet of pipe on hand.

When more than one piece of pipe is used in making a length, it is known as a "run." In making a run, one should allow for the amount of pipe that screws into the fitting as well as the space occupied by the fitting itself. On a permanent job, all threads, especially those of the fittings, should be well coated with white lead before final assembly.

Parallel pipes are measured from center to center. Pipes running at right angles to each other are measured from the center line of one to the end of the other. The size of pipes is designated by their inside diameters.

In pipe fitting, always use white lead or pipe cement in the joints. Pipe and pipe fittings have been standardized so that there is little danger of not being able to purchase the necessary sizes of pipes and fittings.

Pipe Thread Standards. The number of threads to the inch on standard sizes of pipe are as follows: ⅛ inch have 27 threads to the inch; the ¼ inch and the ⅜ inch pipes have 18 threads to the inch. The ½ inch and the ¾ inch pipes have 14 threads to the inch. The 1 inch, the 1¼ inch, the 1½ inch, and the 2 inch pipes have 11½ threads per inch. The larger pipes, such as 2½ inch pipes and larger, are supplied with 8 threads per inch.

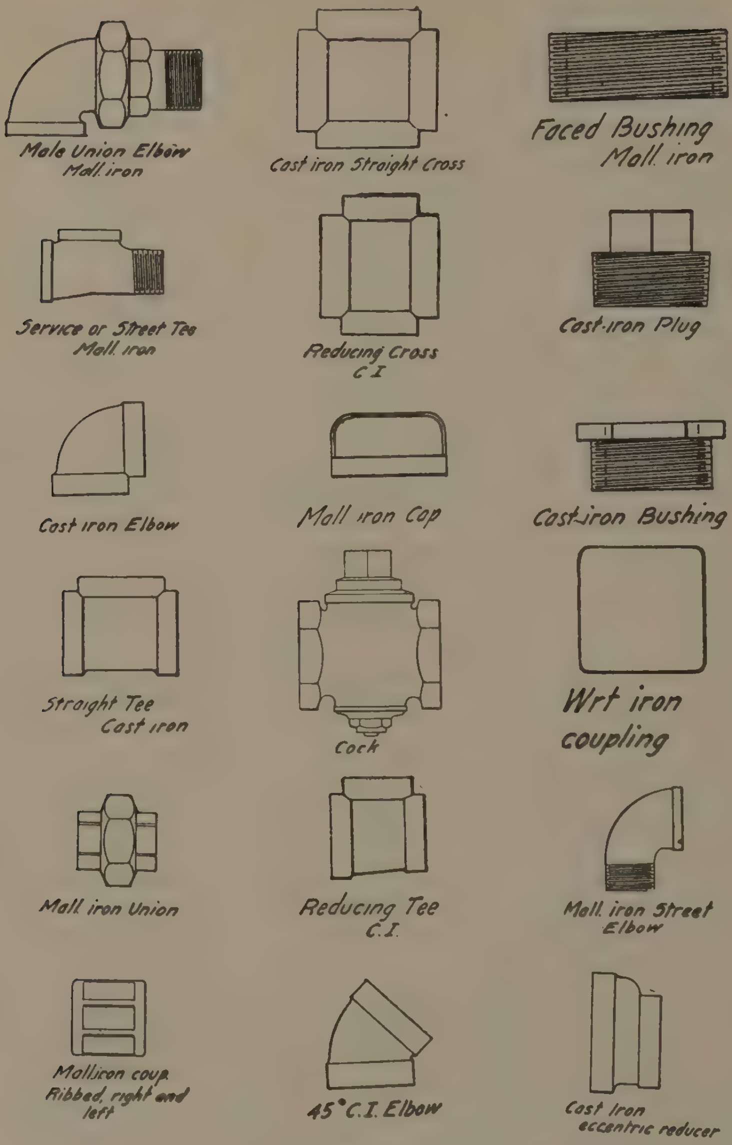


FIG. 101
Fittings for plumbing.

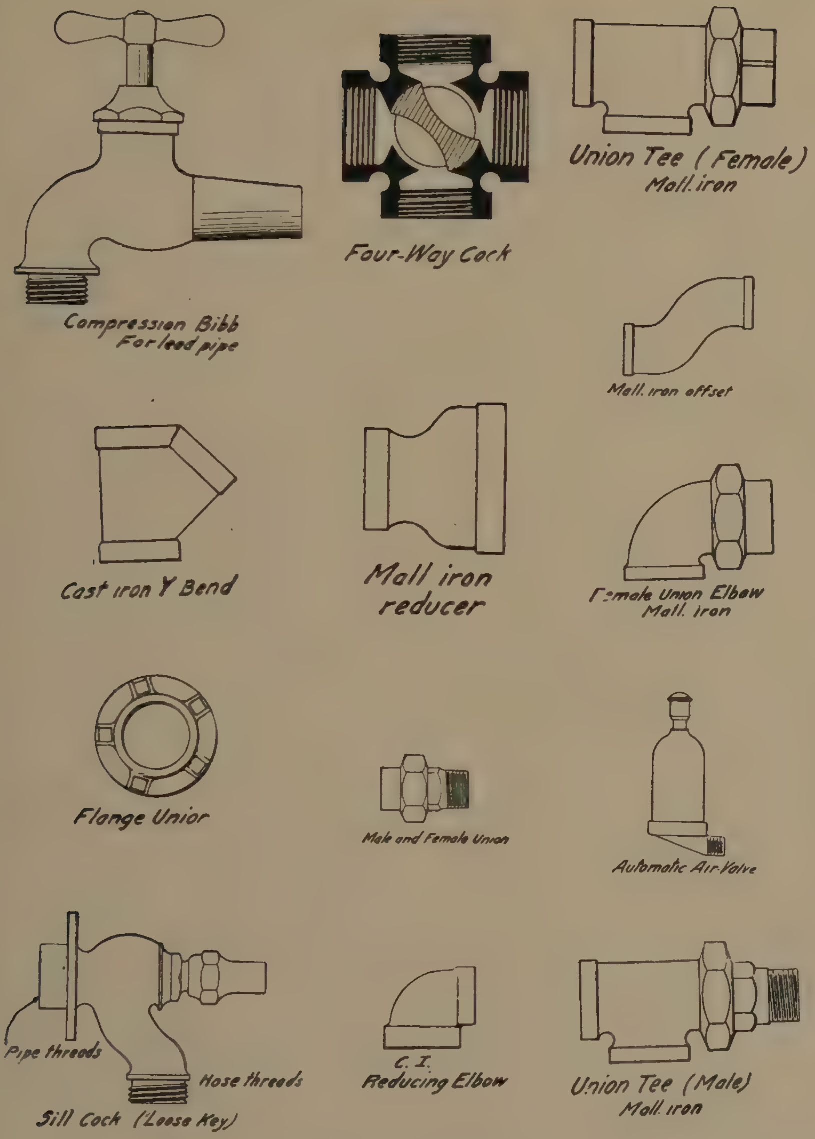


FIG. 101 (contd.)
Fittings for plumbing.

JOB 48

TO CUT, FIT, AND THREAD PIPE TO DEFINITE SPECIFICATIONS

Material and equipment.

Pipe cutter; pipe vise; cup grease; pipe stock and dies; pipe wrench; 12″ half-round file; ¾″ pipe; ¾″ fittings; union; cross; two couplings; three elbows; tee; lock nut; globe valve; ¾″ to ½″ bushing; ½″ plug.

General information.

Practically all of the more common jobs include the use and fitting of a union, cross, coupling elbows, tee, lock nut, globe valve, reducing tee, nipple, and bushing. The simple system, illustrating the use and placings of the various fittings, is shown in Figure 101. The principles of procedure for installing a larger system are the same, except that application of other dimensions will be necessary.

Procedure.

1. Cut the pipe to length as indicated in Figure 102. Figure 103 shows the correct method of using a pipe cutter. Care should be taken to avoid side thrusts when operating the pipe cutter.

2. Ream out the inside burr made by the pipe cutter with the half round file.

3. Cut the proper amount of thread on each pipe. (When the die comes flush with the end of the pipe, the proper amount of thread has been cut.)

   a. Select the proper sized die and guide to fit the pipe. If a solid die is used, be sure that the large diameter is facing the pipe end.

   b. Slide the guide over the pipe.

   c. Hold the handles of the stock at right angles to the length of the pipe to insure a straight thread. Press the die firmly on the pipe and rotate the stock to the right. Apply lard oil freely to the cutting lips of the die.

4. Assemble the pipes and union and cross loosely. Check the distance from the center of the cross to the end of the valve on the water system to determine if any mistakes have been made.

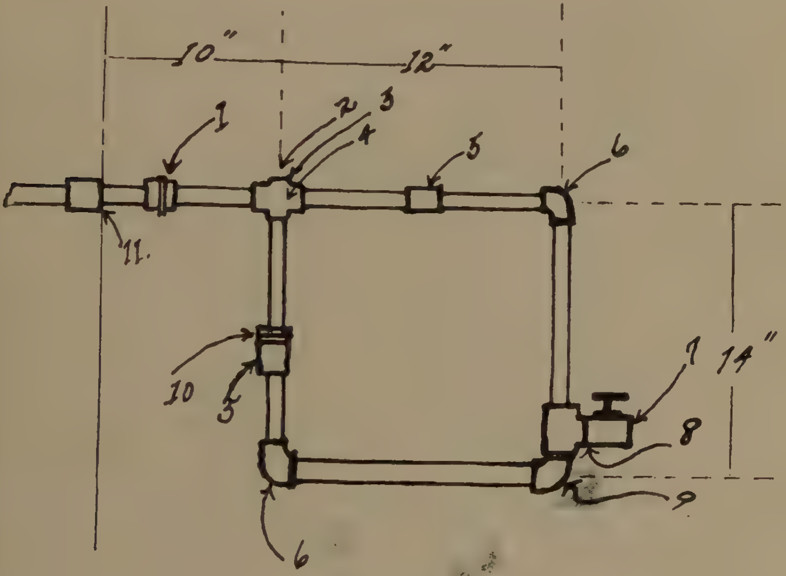


FIG. 102

Diagram of a practice plumbing job.

5. Apply white lead to the threads on the long nipple and screw it solidly into the valve. Turn the female part of the union on solidly.

6. Cut packing for the union as shown in Figure 104.

7. Complete the top and bottom run of the rectangle, always bearing in mind the amount of pipe to allow for the fittings.

8. Make the close nipple as follows:

a. Cut a thread long enough to permit a lock nut and coupling to be screwed on flush with the end of the pipe. This is used as a nipple holder.

b. Cut a regular length of thread on another piece of pipe of the same diameter. Cut this threaded end off one and one-fourth inches long.

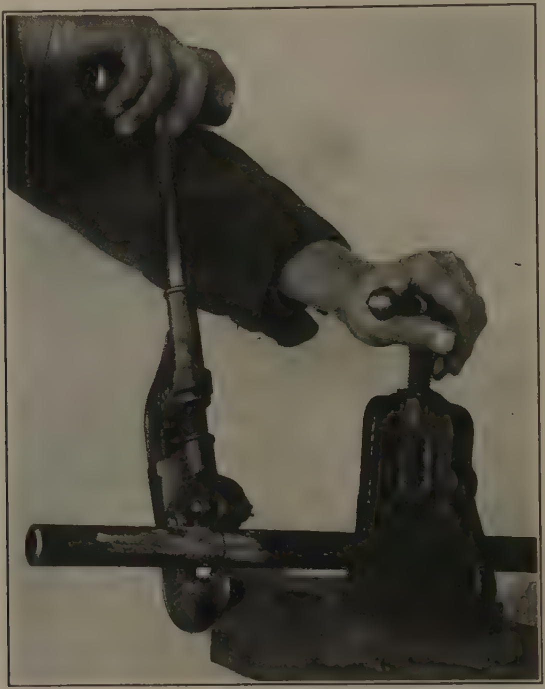


FIG. 103
Cutting pipe.

c. Unscrew the coupling part-way from the long thread and screw the short piece of pipe in snugly with the fingers. Turn the coupling onto the long thread solidly.

d. Fasten the longer pipe in the pipe vise as in Figure 105.

e. Reverse the position of the die in the stock or remove the guide.

f. Thread the nipple. When the threads meet, remove the die by reversing and taking off.

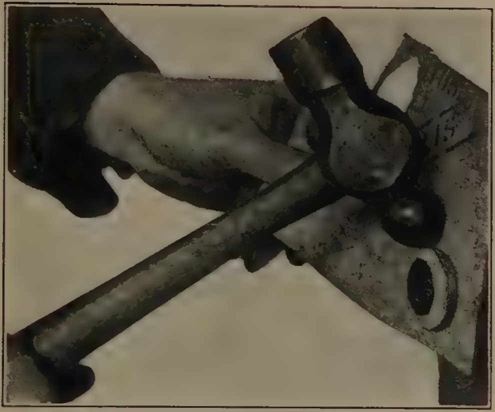


FIG. 104
Cutting packing for a union.

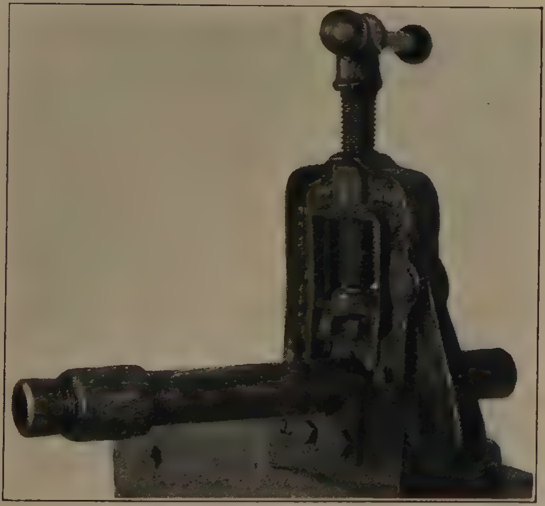


FIG. 105
The pipe in the vise.

g. To release the newly made nipple, unscrew the coupling from the long screw with the pipe wrench.

9. Assemble the job in the order in which it was constructed, applying white lead to each thread and turning all pipes and fittings up tightly.

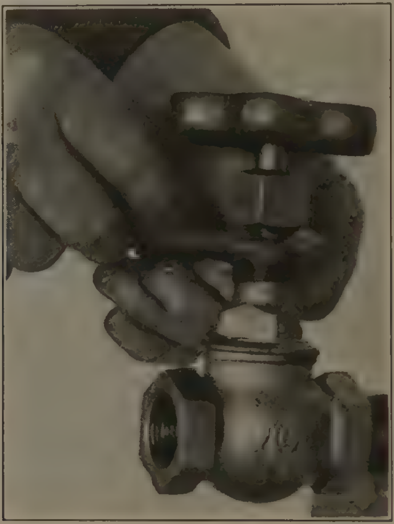


FIG. 106

Packing the valve stem.

10. Fit the pipe with the long screw and the long nipple so that their ends just meet.

Turn the pipes into the lower and upper elbows solidly.

Turn the coupling off the long screw onto the long nipple until it is tight. Apply packing to the reamed end of the coupling and turn the lock nut up against it to make it a tight joint.

11. Remove the packing nut and repack the valve stem as in Figure 106.

References.

Robb and Behrends, *Farm Engineering*, John Wiley & Sons, New York, 1924.

CHAPTER XI

BABBITTING AND BEARING SCRAPING

There are three general classes of bearings: ball-bearings, roller bearings, and plain bearings.

The *plain bearing* consists of a hard shell lined with a soft metal alloy called "babbitt." The real purpose of this babbitt lining or bushing is to protect the expensive shaft, should the lubrication become poor and increased friction result. In case this occurs, the babbitt will melt out, or "burn out," as it is popularly termed, and the shaft will not be ruined.

It is evident that it is cheaper to replace the babbitt bushing than to replace the shaft or have it turned down if it becomes scored.

Babbitt is commonly composed of two or more of the following metals: lead, tin, copper, antimony, and zinc. Tin has a toughening effect on babbitt, while antimony and copper have a hardening effect.

When babbitt is heated, a heavy scum will form on its surface. This is due to formation of oxides of the metals with the oxygen of the air. This scum should be drawn to one side and removed occasionally, care being taken not to waste the good babbitt.

Babbitt bushings are held in place by shallow holes called anchor holes in the shell or by a low flange around the edge of the shell. In some automobile engines the bearing shell is tinned, in which case the babbitt unites directly with the shell.

In packing a box or shell which is being prepared for babbitting, various materials may be used, such as moist clay, putty, or powdered asbestos and steam cylinder oil, thoroughly mixed. The latter is probably the most satisfactory, as it may be subjected to extreme heat without injury. This is sometimes necessary for the best results. It is also very plastic and easy to mold. Powdered asbestos may be obtained through the local plumber. Enough steam cylinder oil should be added to the powdered asbestos to form a thick, stiff, plastic mass.

The *proper alignment of a shaft* before babbitting a bearing is very important and calls for sound judgment and mechanical sense. Each case should be studied and alignment carefully made to insure the most efficient operation of the machine.

Babbitt should be of a proper temperature before being poured. When the babbitt is hot enough to char a pine stick dipped into it, it is of the proper pouring temperature. Care should be exercised not to overheat the babbitt, as this will destroy some of the metals.

JOB 49

TO REPLACE A BABBITT BEARING

Material and equipment.

Plain box or shell with a shaft to fit; large babbitt ladle or kettle, or other iron container and a small ladle; pine stock; some means of heating the babbitt, such as a blow pot or forge; tin-snips; packing compound; cardboard; sheet-metal or shim stock; bearing scraper; Prussian blue or lampblack in oil; wrench; cold-chisel; round-nose chisel; ball-peen hammer.

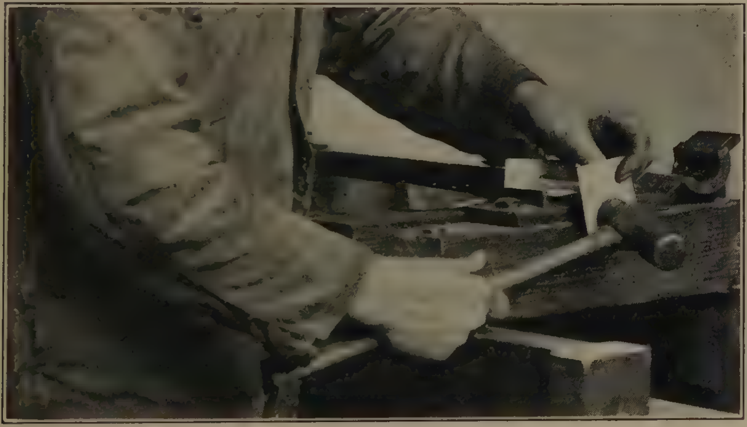


FIG. 107

Cutting pasteboard ends preparatory to pouring the babbitt.

Procedure.

1. Remove the old babbitt by driving a thin cold-chisel between the bushing and the shell, using care not to injure the shell. Another method is to heat the shell with a blow-torch. Put the old babbitt in the ladle and allow it to melt. Be sure that the anchor holes are well cleaned out.

2. Cut pasteboard ends as in Figure 107. Tap very lightly on the shaft so as not to burr it.

3. Cut pasteboard liners as shown in Figure 108. One, you will note, is in place and the saw-toothed edge bears against the shaft. The purpose of these liners is to make it possible to split the bearing after it is poured. The saw-toothed edge permits the babbitt to run through and fill the lower half of the bearing.

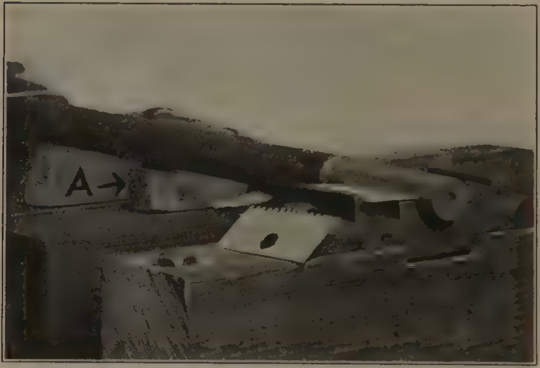


FIG. 108

Preparing the pasteboard liners.

4. Give the shaft or mandrel a thorough covering of soot by holding it over a kerosene flame, or give the shaft a very thick coat of oil and then sprinkle flake graphite over it. The coating of soot or graphite serves as an insulation and prevents the babbitt from becoming chilled when it first strikes the shaft.

5. If a blow-torch is at hand, heat the box.

6. Cut and fit a few extra shims from metal, cardboard, or other convenient material. Each side should be shimmed up quite thickly to insure a thicker layer of babbitt, thus allowing the operator a good margin for fitting the bearing.

7. Assemble the pasteboard ends, shims, and liners.

8. Put the cap on and align the shaft. This may be accomplished in many ways. At (*A*), Figure 108, you will note that tapering pieces of board are used, one on each side. To raise the shaft, they are pushed together. Bolt the cap down solidly.

9. Pack the box or shell. Take a quantity of the packing compound and roll it out like a rope between the hands. Lay it around the shaft and press it together firmly as in Figure 109. This packing compound acts as a retaining wall and prevents the babbitt from leaking out. The oil hole is left open to allow for the pouring of the babbitt.

10. Insert a match or nail on each end between the shell and the pasteboard to allow the escape of any gases which might form as a result of the presence of oil or moisture.

11. Pour the babbitt. Be sure there is sufficient metal in the ladle and that it is of the right temperature. Pour rapidly but steadily until the metal appears well up in the oil hole.

12. As soon as the babbitt has become set, remove the packing and the bolts in the cap.

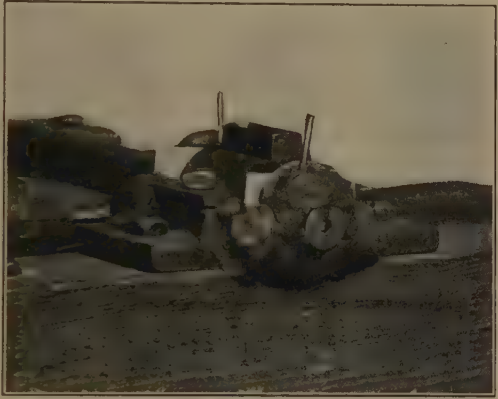


FIG. 109
The box ready to receive the babbitt.

13. Split the bearing by driving a thin cold-chisel between the cap and the base on each side of the shaft or mandrel, as in Figure 110. Perform this same operation on each side of the bearing. If the bushing is defective, that is, if it is rough or contains pits and will not give a satisfactory bearing surface, it will be necessary to re-babbitt the box.

14. Bore out the babbitt in the oil hole with a twist-drill of a size that will not injure the threads.

15. Beginning at the outer corners of the bearing cap, cut shallow grooves with a round-nose chisel to the center oil hole to serve as a channel through which the oil may pass in lubricating the bearing. See Figure 111.

16. Remove any surplus babbitt from the ends and sides where the liners were with a flat bastard file. The babbitt should come flush with the surface of the shell.

17. Scrape the outer surface of the bearing very carefully with the scraper until the clean metal is exposed. In using a scraper, place the flat side against the side of the bearing. Bring the lower cutting edge in contact with the babbitt. Holding the scraper

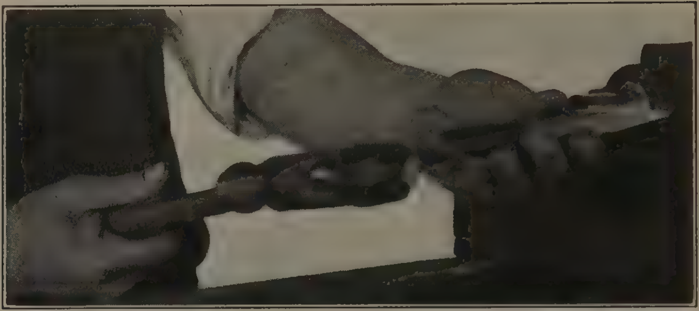


FIG. 110
Splitting the bearing after the babbitt has been poured.

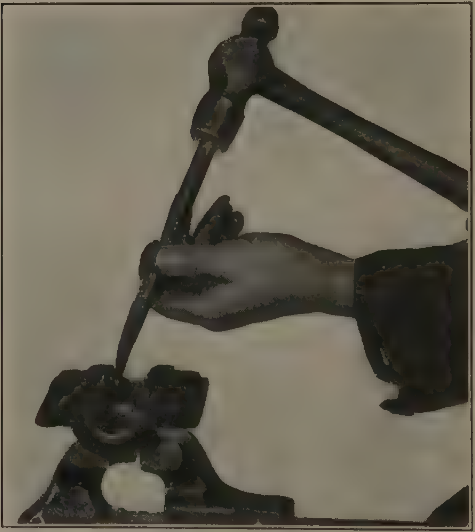


FIG. 111
Cutting oil grooves in the babbitt.

firmly, move it downward and up the other side, cutting away a very thin shaving. Avoid using a choppy method of scraping.

18. Remove enough metal from the sides of the bearing so that the shaft will seat easily in the bottom of the bearing.

19. Apply a very small amount of Prussian blue to the surface of the lower half of the bearing. Put the shaft in place, pressing down heavily on it to rotate it back and forth.

20. Remove the shaft and scrape the high spots which appear shiny. Apply Prussian blue to the newly scraped spots and repeat the above operation until the bearing surface presents a mottled appearance.

21. Put the shaft in place. Bolt the cap on, using no shims. Draw the bolts down until the bearing drags heavily on the shaft when it is rotated. Scrape the cap until it fits well.

22. If the work has been properly done thus far, it will be necessary to have shims between the cap and the base of the bearing on each side to prevent binding when the bolts are drawn down. There should be the same thickness of shims on each side of the bearing. When the cap is drawn down tight, the bearing should drag on the shaft slightly. *Keep new bearings well oiled.*

CHAPTER XII

SOLDERING

The solder commonly used in repair work is known as "half-and-half," being 50 per cent tin and 50 per cent lead.

The tools commonly used in soldering are shown in Figure 112. They are: (1) blow-torch; (2) soldering copper; (3) flat bastard file; (4) tin-snips; (5) scraper; (6) soldering flux; (7) salammoniac; (8) solder; (9) emery-cloth; (10) waste. In the above list of tools the emery-cloth could be dispensed with. One might use the coal stove or forge to heat the soldering copper, thus dispensing with the blow-torch. However, in using the above-mentioned heating devices, the tinned portion of the soldering copper should be protected from the destructive gases of the coal fire by inserting the end of the soldering copper in an old fork-handle ferrule.

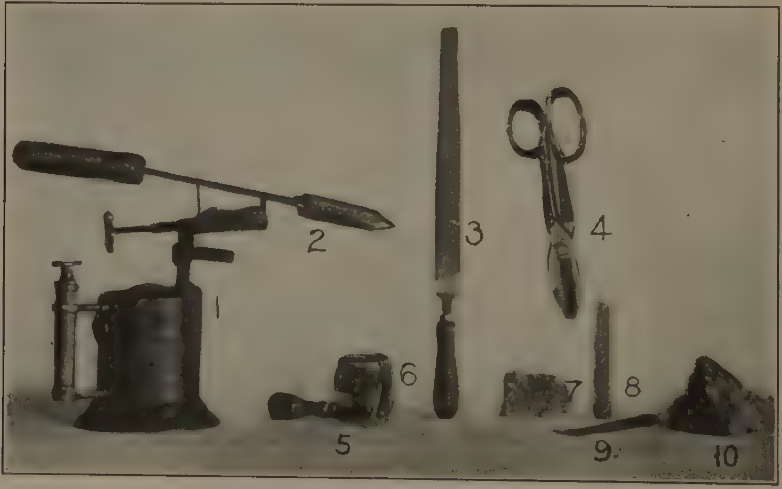


FIG. 112

Tools used in soldering.

A *flux* is a material used in soldering to dissolve oxides or to prevent their formation. In other words, it is a material used to clean the metals in soldering. One of the best fluxes for general repair use is zinc chloride. This flux may be used for cleaning the soldering copper when tinning it.

Salammoniac, used in block form or dissolved in water, serves very well for cleaning the soldering copper preparatory to tinning.

Muriatic acid (hydrochloric acid) is a flux used in soldering galvanized iron, the zinc of the galvanizing uniting with the acid to form zinc chloride. Muriatic acid is also used in soldering cast-iron, steel, and enameled ware. In this case it is applied first in order to dissolve the impurities and any enamel that remains on the parts to be soldered. After the acid has worked on the metals for a short period and zinc chloride or some other flux has been applied, the metals are ready for the solder.

All the above-mentioned fluxes have a corrosive tendency when any surplus is left on the metals.

Rosin and soldering paste are *non-corrosive fluxes* which may be used for cleaning both the soldering copper and the metals.

JOB 50

TO MAKE A ZINC-CHLORIDE FLUX FOR USE IN SOLDERING

Material and equipment.

Porcelain or glass container; muriatic acid; zinc in sheet form, outer walls of discarded dry cells, or glass-jar covers.

Procedure.

1. Pour muriatic acid into the container, quantity depending on the amount of flux desired. However, the container should not be over half full, as the solution may foam over when the zinc is put in.
2. Add small pieces of zinc until all chemical action ceases.
3. Allow the sediment to settle. Then drain off the clear liquid. The clear solution is the flux.
4. For common work the acid should be diluted to one half water.

JOB 51

TO TIN A SOLDERING COPPER

Material and equipment.

Soldering flux; 12″ flat bastard file; vise; blow-torch; half-and-half solder.

Procedure.

1. Heat the copper to a temperature at which it will melt solder readily.

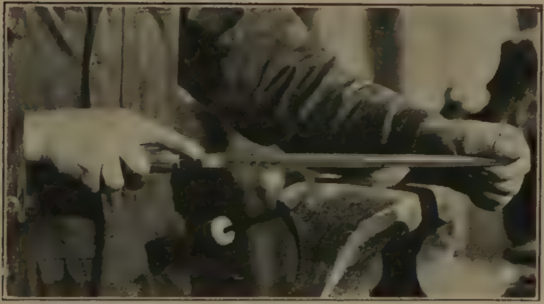


FIG. 113

Cleaning the copper.

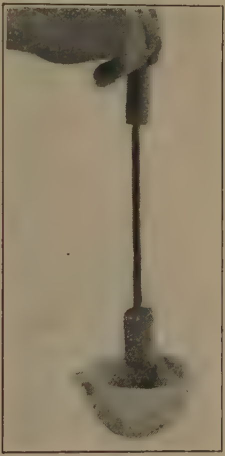


FIG. 114

Dipping the copper in salammoniac.

2. Place it firmly in a vise and file all four sides of the point, as shown in Figure 113, until they appear bright and clean.

3. Round the corners and the point slightly with the file.

4. Heat the copper to its original temperature and dip the point in the salammoniac solution as shown in Figure 114.

5. Place the point of the copper in the solder and rotate it. If the copper has been properly cleaned, the solder will adhere to all four sides of the point.

JOB 52

TO MAKE A SOLDERED LAP-JOINT

Material and equipment.

Blow-torch; tinned soldering copper; soldering flux; solder; tin-snips; sand paper or emery-cloth; sheet-metal.

Procedure.

1. Cut two pieces of sheet-metal 3″ x 3″. Clean a strip one-fourth inch wide along one edge of each with the sandpaper or emery-cloth.

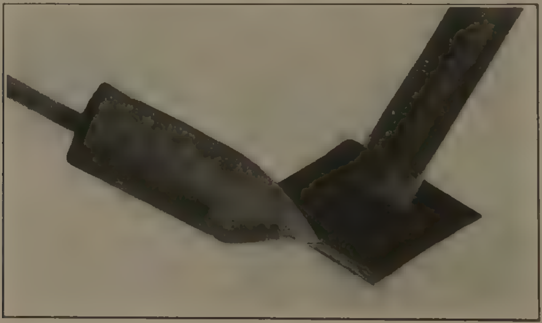


FIG. 115
Tinning the metal.

2. Apply the flux to the cleaned areas.

3. Touch the tinned area of the heated copper to the solder, which may be placed in the middle of a piece of sheet metal bent up around the edges to prevent waste of solder.

4. Draw the tinned area of the copper along the cleaned area of the metals, as in Figure 115. This will bring about a thin deposit of solder. This is termed "tinning the metals."

5. Place the tinned areas one on top of the other, lapping the metals one-eighth to one-fourth inch, and hold them firmly in place with a stick or file.

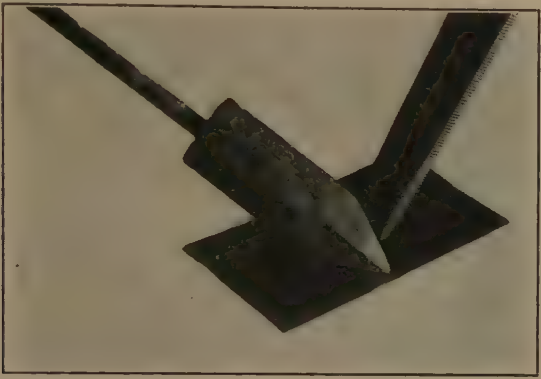


FIG. 116
Making the lap-joint.

6. Renew the deposit of solder on the copper and, starting at one edge, hold the point of the copper against the lap-joint and slowly work the copper along the seam to the other edge of the metals, as in Figure 116. Hold the metals tightly together by moving the file at intervals as the copper is worked along the seam.

7. Turn the metals over and repeat the previous operation along the seam.

JOB 53

TO SOLDER SMALL HOLES IN SHEET-METAL AND HOME UTENSILS

Material and equipment.

Blow-torch; tinned soldering copper; soldering flux; solder; tin-snips; sandpaper or emery-cloth; twist-drill; sheet-metal; pans or pails with small holes in them.

Procedure.

1. Locate all of the holes in the pan or pail on which you are to work.

2. File off the projecting parts of the edges of these holes

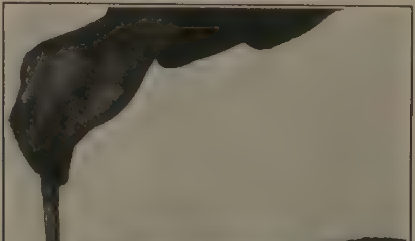


FIG. 117

Cleaning edges of hole to be repaired.

3. Clean them by means of a twist-drill rotated by hand, as in Figure 117, or by doubling the sandpaper or emery-cloth and rotating the corner in the hole.

4. Apply the flux to the hole, being careful not to spread it to the surrounding areas.

5. With a supply of solder on the soldering copper, stick the point in the hole and rotate the copper, as in Figure 118.

6. Lift the copper. The solder should form a rivet in the hole, sealing it perfectly.

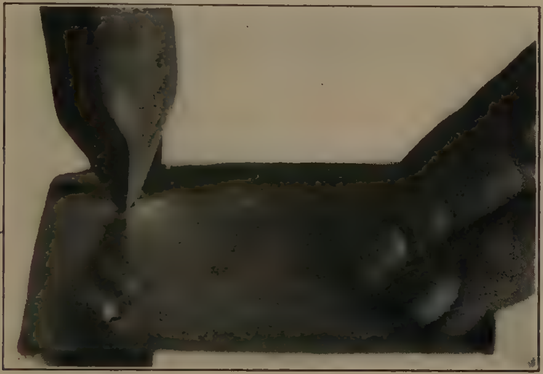


FIG. 118

Sealing the hole with solder.

7. Repeat this operation several times until you become adept at it.

8. When the repair is on enamel ware, it is necessary to remove the enamel covering from the iron. Thoroughly clean the iron. Apply flux and solder as in repairing any piece of iron.

JOB 54

TO MAKE A SOLDERED CORNER, SUCH AS IS OFTEN USED IN THE REPAIR OF SMALL UTENSILS

Material and equipment.

Blow-torch; soldering copper; soldering flux; solder; hammer; sandpaper or emery-cloth; sheet-metal; square-edged board; tin-snips.

Procedure.

1. Cut a piece of sheet-metal 3″ x 4″.
2. Lay it on the board so that one end will project over the edge of the board one-fourth inch.
3. Bend a sharp corner on the metal with the hammer.
4. Clean the inner part of the piece bent down and tin it as in Figure 119.
5. Clean and tin the edge of another piece of metal of similar size.
6. Place the tinned areas of the two pieces of metal as in Figure 120 and sweat them firmly together.

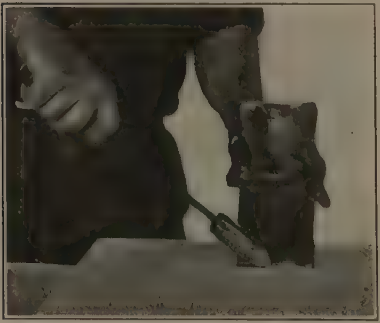


FIG. 119

Tinning the metal for a soldered corner.

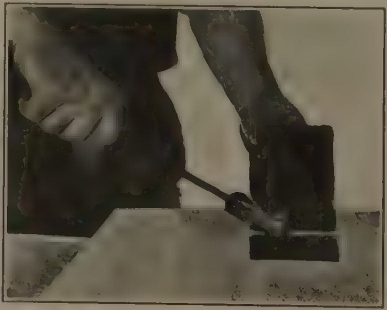


FIG. 120

Sweating the pieces of metal together to form the corner.

JOB 55

TO PATCH A LARGE HOLE IN SHEET-METAL

Material and equipment.

A small piece of sheet-metal for the patch; cold-chisel; hammer; blow-torch; solder; soldering copper; soldering flux; sandpaper or emery-cloth; tin-snips.

Procedure.

1. Pound out all of the ragged edges of the hole, or trim them off.
2. Tin an area of one-fourth inch around the edge of the hole.

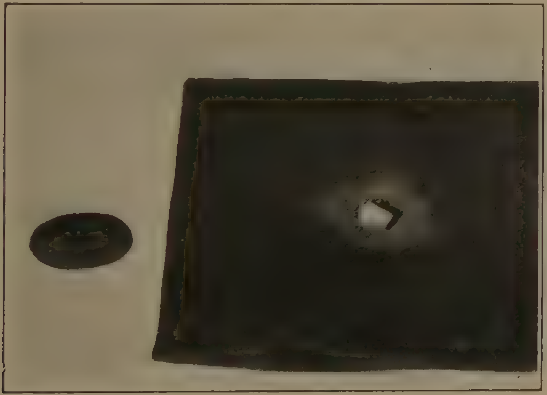


FIG. 121
Patch to be soldered over a large hole.

3. Cut a patch. Make it one-fourth inch larger than the largest diameter of the hole to be patched and tin one surface of it as shown in Figure 121.
4. Place the patch over the hole.

5. Sweat it on solidly by moving the copper about over the surface and edges at intervals as shown in Figure 122.

6. Care must be taken not to loosen the patch by leaving the copper too long in one place.

7. A patch may also be sweated on by heating it with the blowtorch flame. Apply the flame to the patch, moving the flame about the patch and the surrounding area. When the solder reaches the fusing point and the patch settles into place, remove the flame. If there is danger that the solder will run off, place a wet cloth on the soldered area after removing the flame.

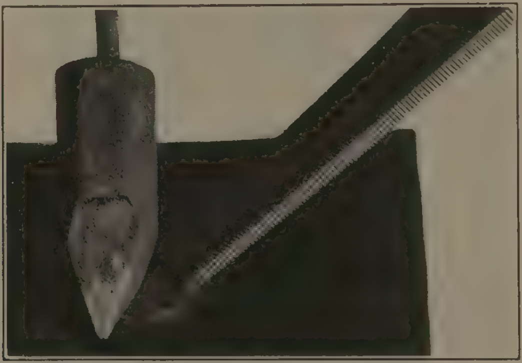


FIG. 122

Sweating on the patch.

8. When *patching galvanized iron*, remember that galvanized iron is iron coated with a thin layer of zinc.

Apply diluted muriatic acid to the surface around the hole. The acid, acting on the zinc coating, bubbles and sends off a vapor. This is similar to making flux, and in this case the flux is made on the job from the metal itself. When action has continued for a minute or two, and while the surface is still wet with the acid, tin the surface as previously described.

JOB 56

TO REPAIR SMALL TUBING SUCH AS THAT EMPLOYED FOR FUEL AND OIL PIPES ON FARM POWER MACHINERY

Material and equipment.

Copper tubing; fine copper or iron wire; sandpaper or emery-cloth; blow-torch; solder; soldering copper; soldering flux; tin-snips; pliers.

Procedure.

1. Holes in copper tubing, as shown in A, Figure 123, often occur.
2. Clean the area around the opening in the tubing.
3. Clean about two feet of wire with emery-cloth or sand-paper.

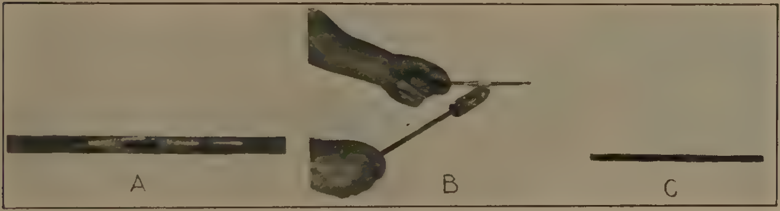


FIG. 123

Repairing a hole in copper tubing.

4. Wrap the wire tightly around the tubing in the region of the hole, allowing the wire to extend at least one-eighth inch beyond each end of the opening, as in C, Figure 123.
5. Apply the flux to the wire, and put a deposit of solder on it in several places.
6. Rotate the tubing on the point of the soldering iron as in B, Figure 123, until the solder is evenly distributed.
7. This method of repairing tubing will not decrease the inside diameter and will make it stronger than it was originally.

HINTS ON SOLDERING

1. A solid joint can be attained only when the metals being soldered are brought to the same temperature as the solder itself.

2. Care must be taken when soldering any metals where the fusing point is near that of solder, such as pewter, zinc, or any of the soft metals. Do not rest the copper on these metals.

3. Steel may be soldered by cleaning the parts thoroughly and applying zinc chloride solution. Cleanliness from grease or dirt is most essential.

4. Articles may often be soldered by tinning the parts, then holding them firmly together and heating them with a blow-torch until the parts are firmly sweated together.

5. In cases where it is difficult to hold the parts in place, dash cold water on the area as soon as the solder is fused thoroughly.

6. Cast-iron may be soldered as follows: first clean the parts, then apply muriatic acid; after a short interval wipe off the acid, apply zinc chloride, and proceed to solder.

7. In some cases, articles may be joined after proper cleaning and fluxing by placing a piece of tin-foil between the parts, then binding them and holding them over a flame until the parts are sweated solidly together.

CHAPTER XIII

GAS-ENGINE MECHANICS

The single-cylinder and multiple-cylinder gas-engines in present-day use are known as *internal combustion engines,* because they burn the fuel within the cylinder. Gas-engines may be two-cycle or four-cycle. By the term *cycle* is meant a constant recurring of events in regular order. For example, spring, summer, fall, and winter constitute a seasonal cycle. Four events constitute a gas-engine cycle—intake, compression, power, and exhaust.

In a *four (stroke)-cycle engine* such as an automobile, tractor, or common single-cylinder farm gas-engine, four strokes of the piston or two revolutions of the fly-wheel are necessary to complete the cycle. As the piston passes from in-center to out-center, the intake valve being open, the fuel mixture is sucked into the cylinder. On the piston's return stroke, both valves being closed, the fuel gases are compressed. As the piston nearly completes the compression stroke, a spark occurs which ignites the fuel mixture. The resulting pressure drives the piston outward, and is called the "power stroke." As the piston approaches out-center, the exhaust valve opens, and on the return stroke the piston forces the burned gases out of the cylinder. This is called the "exhaust stroke."

In the two (stroke)-cycle motor such as is employed in some motor boats and lighting plants two events take place with each stroke. When the compression stroke takes place fuel is drawn (sucked) into the crank case. When the power stroke is nearly completed the exhaust and intake ports in the cylinder wall are opened. As the piston reaches out-center the exhaust gases rush out on one side and fuel under pressure caused by the descending piston rushes into the cylinder from the crank case. The new fuel strikes a deflector on the piston and turns upward forcing the remaining exhaust gases out and filling the cylinder with fresh fuel ready for the compression stroke. Thus it is evident that only one revolution of the flywheel is necessary to complete the gas-engine cycle. In general the two-cycle motor is lubricated by mixing a certain quantity of lubricating oil with the fuel. Good lubrication by this method is difficult.

There are *six essentials necessary for the successful operation of a modern gas-engine:*

1. Good compression of the charge
2. Proper valve action and timing
3. Proper fuel mixture in the cylinder
4. Good spark at the right time
5. Correct lubrication
6. Proper cooling

JOB 57

TO OVERHAUL A SINGLE-CYLINDER GAS-ENGINE

Material and equipment.

Single-cylinder gas-engine; set of socket wrenches; screwdriver; pliers; jack-knife; putty knife; tin-snips; narrow, thin strips of metal; kerosene; a clean cloth or waste.

Procedure.

1. Inspect the engine very carefully so that you may know its general make-up. Note the manner of governing. Test the compression.

2. Remove the following parts in the order named: cylinder head, intake and exhaust valves, connecting rod, piston, and ignitor.

3. Remove the rings from the piston by slipping four thin pieces of metal beneath them. Start the pieces of metal near the opening of the ring and work them around until they are about an equal distance apart. Slide the ring off the piston-head carefully. Each ring should be marked with a very small notch on the upper inner corner so that it may be replaced in its proper groove.

4. Clean all dirt and carbon from the piston-head and the ring grooves; then wash the piston in kerosene.

5. Scrape the carbon out of the cylinder head.

6. The rings should be installed in their proper grooves by means of the same small metal strips.

7. Note whether the crank-shaft bearings are loose. If they are, remove enough shims, the same number from each side, from one bearing so that when the nuts are drawn down tight on the main bearing bolts, there will be a slight drag on the crank-shaft when the fly-wheel is revolved by hand.

8. Loosen the bearing and proceed to take up the other main bearing.

9. Leave both main bearings loose.

10. Install the piston, with the oil hole for the piston pin up. Place the openings of the piston rings an equal distance apart. Compress the rings by means of a ring compressor or large, stiff wire as they approach the cylinder bore.

11. Take the connecting-rod bearing up in a manner similar to that in which the main bearings are taken up.

12. Apply a small amount of light oil to the bearing surfaces, then draw the connecting-rod bearing and main bearings down tight.

13. Apply kerosene to all moving parts of the governor.

14. Clean the ignitor points or the spark-plug. Grinding valves, the timing of valves, and ignition are dealt with in following jobs.

15. If the piston pin or piston-pin bushing is badly worn, the assembly should be taken to a shop equipped for such work.

JOB 58

TO GRIND THE VALVES AND SCRAPE THE CARBON IN A GAS-ENGINE

Material and equipment.

Engine of one or more cylinders; 12″ mill bastard file; valve lifter; light coil spring; thickness gauge; valve-grinding compound; pliers; small center punch; wrench for removing cylinder head; clean rags; putty knife; valve-grinding tool (a large screwdriver generally serves well).

General information.

Loss of power, irregular firing at slow speed, and overheating of the motor may indicate leaky valves and excessive carbon deposit.

In *testing for leaky valves,* try the compression by cranking the motor over slowly. If the compression is good, a springy resistance as each piston comes up against compression will be felt. By putting your ear to the exhaust you can hear the leak. This is the surest method.

Leaky intake valves may be indicated by a regular spitting back or hissing in the carburetor. A leaky exhaust valve may be detected by a hissing noise in the exhaust manifold when the piston is brought up against compression.

A noise similar to exploding in the muffler indicates a *sticking exhaust valve.* The valve may be sticking because of a bent stem or an excessive deposit of carbon and gummy oil in the valve-stem guide or on the valve stem.

A clicking noise when the motor is laboring, when the spark is retarded properly, indicates preignition due to *excessive carbon.*

There are so many types of engines in use to-day that one must depend upon good judgment when removing valves, rather than upon any one set of rules. One should be very careful not to bend the stem of the valve. In *breaking the cylinder head loose,* do not use a cold-chisel and hammer or screw-driver, as the gasket may be ruined by so doing. Often a head that sticks solidly may be removed by turning the engine over against compression and at the same time striking a block of wood held against the head a solid blow. All holes, such as the cap-screw holes and water circulation holes, should be filled lightly with small pieces of cloth or waste to keep out particles of carbon. Scrape the carbon off the piston-heads, valve heads, and around the parts with a stiff putty knife, wire brush, or some similar tool.

Examine the valves for marks. If they are not marked, mark them by putting one light center-punch mark near the center of number one valve (number one cylinder is the one farthest from the fly-wheel). Mark the next valve in order with two dots, the next one with three, and so on, to the last valve. Make certain that each valve is seated before marking it.

Steel and iron will expand when subjected to heat. If no space or clearance were allowed between the end of the valve stem and the valve tappet when the engine was cold, the valve could not seat properly when heated. *Grinding valves* tends to let the valves be seated down farther in the seat, and results in decreasing the valve-stem clearance. This clearance can be regulated by adjusting the push rod or the valve tappet in most cases. Where these are not adjustable, the end of the valve stem should be ground to the proper clearance. On most automobile engines this clearance runs from three-thousandths to eight-thousandths inch. On trucks and buses it is nearly twice this amount; and on some tractors, it is as much as thirty-one thousandths inch.

Procedure.

1. Place number one cylinder on top-center with both valves closed.

2. By means of the valve lifter (if L-head), raise the valve spring until the retainer pin or washer can be removed.

3. Remove the valve: inspect it and seat it carefully. When the seat has lost its correct bevel or becomes pitted, it must be reconditioned by means of a valve-seat reamer.

4. Clean away deposits of carbon below the valve seat.

5. If the valve has become grooved or pitted, file the face as shown in Figure 124. Rotate the valve so as to avoid filing flat spots on the face.

6. Put a thin coating of grinding compound on the valve face. Place the light coil spring over the stem so as to raise the valve head from the valve seat when grinding.

7. Put the valve in its proper place.

8. Using a screw-driver or valve-grinding tool, press the valve down on its seat lightly. Rotate the valve one-fourth of a revolution back and forth allowing it to rise from the seat at the end of each stroke, thereby distributing the compound. After a few strokes, change to a new quarter.

9. When the compound loses its body, wipe the face and seat clean and note the progress made. Continue grinding until an even gray band appears on the seat and face.

10. Be certain that all grinding compound is wiped off both the seat and the valve with a clean cloth or waste.

11. Test the seat by making several pencil marks across the face at regular intervals; replace it in its proper position and, applying considerable pressure, rotate it one-fourth of a revolution. The marks should be wiped off the width of the seat if the valve is tight.

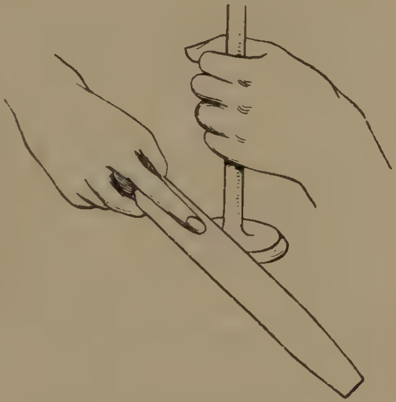


FIG. 124
Filing a valve to remove pits or grooves.

12. Apply a small amount of light oil to the stem and then replace the valve.

13. Compress the spring and replace the washer and key.

14. Proceed with the other valves as directed above.

15. Adjust the tappets to the clearance recommended by the manufacturer. Note the clearance after the seat unit is tight.

JOB 59

TO TIME THE EXHAUST VALVE ON A SIMPLE STATIONARY GAS-ENGINE

Material and equipment.

Stationary engine; tool kit; measuring tape.

Procedure.

1. Remove cam gear from engine.

2. Find the circumference of fly-wheel in inches.

3. Note the rated revolutions per minute as stamped on the engine by the manufacturer.

4. The following rule is quite generally accepted for setting the exhaust valve:

"Set the exhaust valve to open 5° ahead of out-center for every hundred R. P. M. of the engine."

There are 360° in a circle, hence, 360° around the fly-wheel. Divide 360° by the number of inches around the fly-wheel. This gives the number of degrees per inch.

Example: The Blank engine has a rated speed of 500 R. P. M. and the fly-wheel measures ninety inches in circumference. To find the number of degrees ahead of out-center that the exhaust valve must start to open, divide 360° by 90, which gives 4° per inch on the periphery of the fly-wheel. Five degrees multiplied by 5 equals 25° ahead of out-center that the exhaust valve should begin to open. Twenty-five degrees divided by 4° equals six and one-fourth inches ahead of out-center that the exhaust valve must open.

5. Place the piston on out-center.

6. Make a chalk mark across the fly-wheel just opposite some definite bolt or piece of the engine.

7. Measure forward six and one-fourth inches and mark across the fly-wheel.

8. Rotate the fly-wheel backward until the last mark made is opposite the above (7) chosen point.

9. Mesh the cam gear so that the exhaust valve is just starting to open.

10. You may now check the timing by rotating the fly-wheel forward, watching the opening of the exhaust valve and also its closing.

IT SHOULD CLOSE AT OR A TRIFLE AFTER INNER DEAD-CENTER!

11. Adjust the set screw on the rocker arm to make up for any small difference in timing that cannot be arrived at by a change of one tooth on the cam gear.

12. Many engines use the same cam or cam gear for valve operation and ignition. In such cases the large or blunt point of the cam is used in timing valves.

JOB 60

TO WIRE A GIVEN NUMBER OF DRY CELLS IN SERIES, PARALLEL, AND MULTIPLE CIRCUITS; TO WIRE AND START AN ENGINE WITH A MAKE-AND-BREAK IGNITION SYSTEM AND ONE HAVING A JUMP-SPARK IGNITION SYSTEM

Material and equipment.

Eight dry cells; wire; set of four dry cells in box with switch; volt-ameter; spark-coil; induction coil; two engines, one using make-and-break ignition and the other jump-spark ignition.

Procedure.

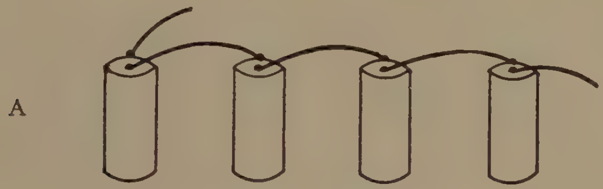
1. Determine the voltage and the amperage of each cell by use of the ammeter.

2. Connect four cells in *series* as in A, Figure 125 (this is the wiring used in all ignition work) and make a record of voltage and amperage. This connection increases the voltage, but not the amperage.

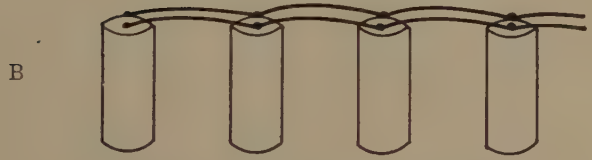
3. Connect the same four cells in *parallel* as in B, Figure 125, and record the voltage. DO NOT TRY TO TAKE THE READING IN AMPERES WITH THE AMMETER, AS THIS CONNECTION INCREASES THE AMPERAGE TO SUCH AN EXTENT THAT IT WILL BURN OUT THE AMMETER.

4. Wire both sets of four cells each in series and then connect these two sets in parallel, as in C, Figure 125. This connection is called "multiple" and is used in ignition circuits where two sets of four cells are used. When four cells are too low in amperage to start the engine, the *multiple connection* is used.

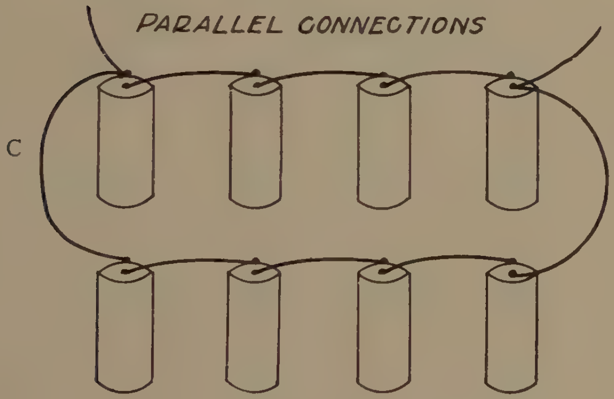
This multiple connection maintains the voltage of four cells in series, but increases the amperage to that of the two sets.



SERIES CONNECTIONS



PARALLEL CONNECTIONS



MULTIPLE CONNECTIONS

FIG. 125

Wiring of dry cells.

5. Disconnect the eight cells and wire four cells in series. Secure the proper coil and a sufficient number of long wires. Wire an engine and start it.

6. A, Figure 126 shows how to wire a make-and-break ignition system.

7. B, Figure 126, shows how to wire a jump-spark ignition system.

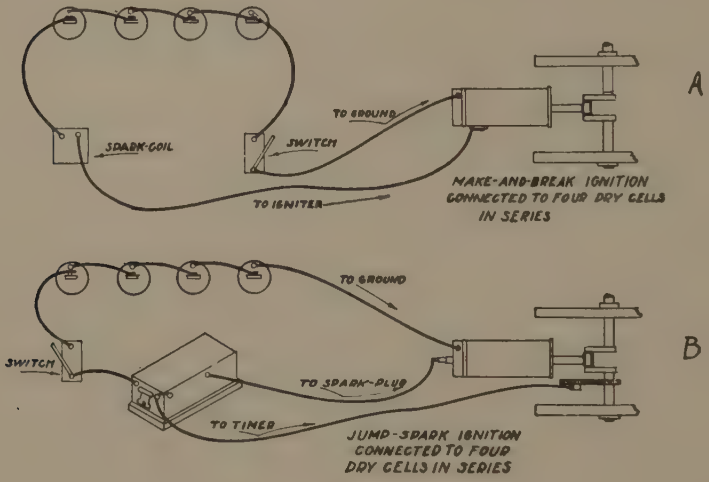

TO GROUND
SWITCH
SPARK-COIL
TO IGNITER
A
MAKE-AND-BREAK IGNITION CONNECTED TO FOUR DRY CELLS IN SERIES
TO GROUND
SWITCH
TO SPARK-PLUG
TO TIMER
B
JUMP-SPARK IGNITION CONNECTED TO FOUR DRY CELLS IN SERIES

FIG. 126
Make-and-break ignition

JOB 61

TO TIME THE IGNITION ON A STATIONARY GAS-ENGINE

Material and equipment.

Stationary engine; set of four dry cells in box with switch; proper coil; wires; tool kit; measuring tape.

Procedure.

1. Make certain that the exhaust valve is timed correctly, as faulty setting of the valve must be corrected before proceeding to time the ignition.

2. Find the inner dead-center and place the piston in this position at the end of the compression stroke.

3. Place the spark advance lever at full retard.

4. Now set the ignitor trip arm so that it just trips or snaps at this point. On a jump-spark engine, see that the breaker points are just beginning to open. If this is *carefully* done, there should never be any difficulty with ignition timing.

On engines using an *oscillating magneto* (which is make-and-break ignition) the same rules are followed, but one must also be sure that the trip arm gives a sufficient throw to the magneto rotor or oscillator to insure a good spark before it trips.

JOB 62

TO INSTALL NEW PISTON-RINGS

Material and equipment.

Tool kit; piston needing new rings; piston-rings; small mill file; a level horizontal surface; thickness gauge; machinist's vise; fine emery-cloth; lubricating oil.

General information.

Piston-rings serve as packing around the piston to hold compression, to prevent loss of the explosive force, and to keep the oil in the crank-case from getting into the combustion chamber. When spark-plugs become fouled and large carbon deposits in the combustion chamber become evident from preignition knocks, the rings are probably worn and need replacing. Extreme care should be exercised in the removal and application of rings to the piston. Never remove a ring over the skirt of the piston, as it may unnecessarily scratch the polished surface.

Excessive wear on a piston-ring is due to: (1) fitting ring too tightly (not enough end clearance), (2) running engine too hot, or (3) lack of lubrication, (4) all of the above together.

Procedure.

1. Remove connecting-rod bearing, being careful to mark the rod and its cap with a center punch so that the cap may be replaced correctly.

2. Remove the piston and rod assembly from the engine.

3. By means of thin metal strips, remove the old rings.

4. Clean the ring grooves thoroughly. A screw-driver or similar tool may be used for cleaning ring grooves.

5. Place a piston-ring in the groove to check its fit. The ring should fit snugly clear to the bottom of the groove. If the rings fit

too tightly, grind them down on the side by moving them about on a piece of fine emery-cloth laid flat on the level surface. Piston-rings should fit snugly but yet move freely in the ring groove.

6. Place two rings side by side in the bore of the cylinder and note their end clearance. The end clearance should be in general two-thousands inch for each one inch in cylinder diameter. Place the file in the vise and file the ring ends to proper clearance by moving the ring end along the file. Be very careful to maintain the original shape of the end.

7. By means of the metal strips used in removing the old rings, slip the bottom ring down to its place, and then each in its order.

8. Apply a thin coating of oil to the piston assembly and cylinder wall and replace the piston assembly in its proper cylinder, being careful that the ring openings are spaced at an equal distance around the piston.

9. Take up the connecting-rod bearing at this time if necessary. The motor should be run carefully for a time after new rings are installed so that they will become fitted smoothly and take on a glaze or polish.

JOB 63

TO ADJUST CONNECTING-ROD BEARINGS

Material and equipment.

Gas-engine needing repair; tool kit; machinist's vise; mill file.

General information.

A metallic knock when the engine is running idle usually indicates a loose connecting-rod bearing. If the spark-plug is short-circuited, the intensity is usually decreased, only to reoccur more plainly for an instant when ignition is allowed. A loose wrist-pin knock is usually considerably intensified when the plug is shorted. When a lower connecting-rod bearing is slightly loose, the knock is seldom noticeable until the engine is warmed up and the oil has become more fluid.

Procedure.

1. Expose connecting-rod bearings by removing the crank-case plate or bottom of the crank-case.
2. Move the rod up and down to ascertain the amount of looseness of the bearing.
3. Mark each bearing shell before removing to insure its being replaced correctly.
4. Remove the cotter pins, nuts, and bearing caps, being careful not to get the shims mixed or injured.
5. Remove one thin shim at a time from each side of the bearing and draw the cap up tight. Enough shims should be removed so that when the cap is drawn up tight there will be just a very slight drag when the motor is turned over by hand.
6. Loosen the connecting-rod bolt nuts one-half turn and proceed to take up the next loose connecting-rod bearing.
7. Tighten all of the bearing caps well, using care not to draw

the nuts so tight that the threads will be stripped or the bolts stretched.

8. Insert new cotter pins and spread them well.

9. In cases where shims are not used, an equal amount must be filed from each side of the bearing cap. The nuts should be drawn up well or the bearing will loosen very quickly with possible danger that the rod will jerk free from the crank-pin.

JOB 64

TO ADJUST MAIN BEARINGS

Material and equipment.

Gas-engine; tool kit; machinist's vise; mill file.

General information.

A loose main bearing is indicated by a dull, heavy pounding when the engine is laboring.

In *testing the main bearings* on a four-cylinder engine the following tests work successfully: If the front main bearing is loose, the knock should disappear when number one spark-plug is shorted. A middle main-bearing knock will disappear when spark-plugs numbers two and three are shorted. A rear main-bearing knock will disappear when number four plug is shorted.

Procedure.

1. Drain off the oil.

2. Expose the main bearings by removing the bottom part of the crank-case.

3. With a heavy bar, pry up on the crank-shaft near each main bearing. Note the looseness of the bearing by oil bubbles or noticeable play.

4. Make certain that each bearing cap is plainly marked to insure its being returned to the proper place.

5. Remove cotter pins and nuts from the loose bearing and take off the cap, being careful not to mix or injure the shims.

6. Take out a shim of equal thickness from each side of the bearing and draw the cap up snugly in place. If, on testing, there still remains play, remove shims until on turning the motor over by hand you feel a slight drag on the crank-shaft.

7. Loosen the nuts one turn and proceed to tighten the next loose main bearing.

8. Draw up all main bearing caps in a similar manner. Note that all cotter-pin holes are in line with the castellated parts on the nuts.

Do not loosen a nut, as this loosens the bearing. It is better to file the nut slightly to make it fit into its place.

9. Test the job by turning the crank-shaft over. The tightened bearings will cause considerable resistance in cranking.

10. Insert new cotter pins and spread them well.

JOB 65

TO TIME THE VALVES ON A MULTIPLE-CYLINDER GAS-ENGINE

Material and equipment.

Gas-engine; tool kit; machinist's vise; mill file.

General information.

Valves which are improperly timed will cause lack of power and overheating of the motor.

Procedure.

1. Place number one piston 5° to 10° past inner dead-center.
2. See that the exhaust-valve tappet is adjusted to the proper clearance.
3. Rotate the cam shaft in its correct direction of rotation until number one exhaust valve has just finished closing.
4. Insert the idler or mesh the cam gear with the crank gear to the nearest tooth and the valves are timed.

Note.—Many engines have the cam-gear and crank-gear teeth marked. This obviously simplifies valve timing.

JOB 66

TO TIME THE IGNITION ON A MULTIPLE-CYLINDER ENGINE

Material and equipment.

Gas-engine; tool kit; machinist's vise; mill file.

General information.

Improper timing of the ignition causes overheating and loss of power.

Procedure.

1. Determine the firing order by observing the action of the valves. Turn the motor over slowly with the crank. You will note that the exhaust valve opens and is quickly followed by the intake valve. Select the exhaust valve for each cylinder and note the sequence of the valves in opening, which is the firing order of the motor.

2. Put piston number one at the beginning of the power stroke or on top of dead-center. This can be accomplished as follows: Turn the motor over until the intake valve closes. Then insert a wire into the cylinder through the spark-plug hole. As the motor is turned slowly over, the piston will push the wire out. When the wire ceases to rise, the piston is at top dead-center at the beginning of the power stroke.

3. If spark-plug wires are attached, turn the distributor arm toward number one segment on the timer or distributor head. If they are not, begin by attaching number one segment wire to number one cylinder and then attach each succeeding wire in the direction in which the motor turns to the next cylinder in the determined firing order.

4. Set the spark lever at full retard.

5. Set the breaker-point cam so that the breaker points are just beginning to open. In the case of a magneto, rotate the magneto

in its proper direction of rotation until the breaker points are just beginning to open, then fasten the coupling securely. If the magneto is equipped with an impulse starter, disengage the impulse before attempting to time the magneto.

The impulse starter should trip on dead-center or one or two degrees after dead-center, so as to make the engine safe for cranking. Check by turning the engine over slowly and note the position of the crank in relation to center when the impulse starter trips.

JOB 67

TO OPERATE A TRACTOR ON A DRAW-BAR AND IN THE BELT

Material and equipment.

Tractor; fuel; oil; grease; water.

Procedure.

1. Read carefully the instruction manual that comes with the tractor.

2. Before attempting to start the engine, see that all grease cups are filled, that there is sufficient oil in the crank-case or oiler, fuel in the tank, and water in the radiator. See that the clutch is disengaged and the gear shift is in neutral position, that the fuel (gasoline for starting) is turned on, and that the switch is on and the impulse starter engaged on the magneto.

3. It is sometimes necessary to prime the engine with gasoline by means of priming cocks. Hold the choke lever on the carburetor while the engine is being rotated for one full turn, then open it. The engine should start upon the second turn.

4. If the engine speed is regulated by a hand throttle, be careful that it is so set that the engine does not race. After the engine has been run for about ten minutes under a good load, or after it has been run under a light load long enough to get the engine well warmed up, switch the fuel valve from gasoline to kerosene. Never attempt to burn kerosene in a cool engine, that is, an engine which is not hot enough to vaporize kerosene.

5. Before attempting to shift gears, be certain that the clutch is disengaged and the pulley stopped. Practise shifting gears and moving the tractor back and forth several times until thoroughly acquainted with how it should be handled. Become accustomed to using the brake.

6. When you have confidence in your ability as an operator, try

backing up to implements such as plows, hitching on to them, stopping on a definite spot, and getting the tractor out of difficult places.

7. Lining up in the belt requires practice and skill. If done systematically, it is quite easily accomplished. Pull the machine to which you are going to belt into the desired position. When possible, bring the tractor around into belt position by moving in one semicircle. Try to do this quickly. The following points are to be observed in lining up:

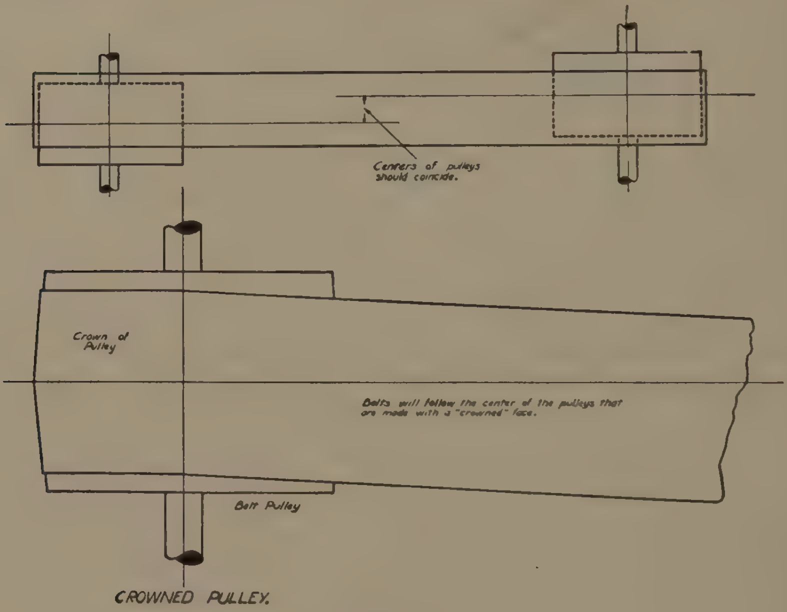

Centers of pulleys should coincide.
Crown of Pulley
Belts will follow the center of the pulleys that are made with a "crowned" face.
Belt Pulley
CROWNED PULLEY.

FIG. 127

Lining the tractor in the belt.

a. See that the tractor is squarely in line with the machine to which it is being belted. See Figure 127.

b. Three points must be in a straight line: (1) center of pulley on the tractor with (2) center of the pulley on the machine and (3) with some other point on the machine that is in line with the center of its pulley. On a grain separator, the side frame and center of pulley usually line up.

c. If a twist belt is to be used, care should be taken to get the correct twist.

Caution.—While running the tractor be sure that the oil is circulating and never clash the gears when shifting. Do Not Get Excited.

Gasoline or kerosene vapor must be mixed with the proper amount of oxygen before complete combustion is possible. This process of mixing is called carburetion. Low-test fuel is much more difficult to carburet properly than high-test. Tractors are usually provided with some means of heating the intake manifold, which tends to cause a more perfect vaporization of the fuel and a better combination of air and fuel vapors. For complete combustion, gasoline requires seventeen or eighteen parts of air to one of gasoline by weight. In actual practice it is found that the mixture will burn if we have from 12-1 to 21-1, as the proportion 12-1 may be called very rich, and 21-1 a weak mixture. The problem in carburetor design is to keep the mixture of such a strength that a rapidly burning mixture will be obtained at all speeds and all loads, since the compression changes with speed or load in the throttle-governed engine.

The simple carburetor shown in Figure 128 consists of a float chamber and mechanism which keeps a constant level of fuel in the jet. The jet, which is placed in a pipe connected to the inlet valves of the engine, is considered to be a nozzle with a plain orifice. A valve or throttle is placed above the jet to regulate the quantity or mixture supplied to the engine and thus governs engine speed. The reduction in pressure in the induction pipe around the jet therefore depends upon the throttle opening.

The speed at which the air is passing up the pipe depends, for a given bore or stroke, upon the revolutions per minute of the engine and the diameter of the pipe, so that by reducing the diameter, we increase the speed of the air. The quantity of fuel issuing from the jet is dependent upon the reduction of pressure set up at that point in the pipe, but this reduction of pressure is not directly proportional to air speed, so that by doubling our engine speed by opening the throttle, we more than double the quantity of fuel in proportion to air passing. That is, with a carburetor of the simple type, we get a richer and richer mixture as we open the throttle until a point is reached when the mixture is not combustible and the engine stops. A carburetor must be automatic so as to meter out the correct proportion of air and fuel at all engine speeds and all loads.

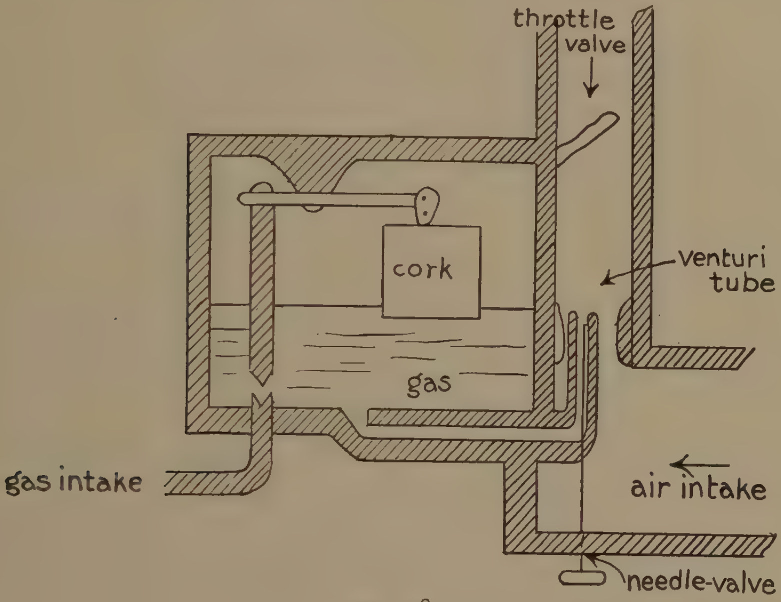


FIG. 128
Diagram of a carburetor.

JOB 68

TO CLEAN OUT AND ADJUST A CARBURETOR

Material and equipment.

One or more multiple-cylinder engines; kit of tools; small can or dish of gasoline.

Procedure.

1. Examine carefully all parts of carburetion system, such as fuel valve or shut-off under tank, fuel line, strainer, two-way valve for kerosene and gasoline, speed controls, and the like, before removing any parts.

2. Shut fuel valve at tank and disconnect fuel line at carburetor, then open valve for an instant and note whether fuel runs out freely.

3. Remove strainer from sediment trap (which is easily done); remove float and check valve from carburetor and sediment cups beneath jets or gas well. Clean them thoroughly in gasoline and flush out the bowl to remove any dirt or water.

4. If the float has become heavy due to a leak in metal construction, or is gasoline-soaked, as a cork float sometimes is, it must be repaired. Otherwise the carburetor will flood or run over. Repair a metal float by soldering lightly; dry a cork float overnight before applying several coats of thin shellac.

5. Replace all parts carefully and tighten all nuts or connections firmly.

6. See that air vent on tank is open.

7. Turn on fuel at tank and open needle-valve one to two turns. Start the engine in the usual way. When warmed up, slowly turn needle-valve down until the engine backfires and then open it one-fourth to one-half turn or until the engine runs evenly. The idling adjustment must be set with the engine running as slowly as it will without missing.

8. Test all manifold and carburetor flange gaskets for air leaks by applying a small quantity of light oil to them while the engine is running. If they leak, the oil will be sucked into the engine.

9. The air cleaner or washer on a tractor must be flushed out or freed of all sediment if you expect the carburetor to operate successfully.

Note.—In almost every instance where an engine fails to run properly, the amateur mechanic begins to adjust the carburetor, probably because it is the easiest thing to put his hands on. Never change adjustments on any carburetor unless you *first know what you are doing.*

LUBRICATION OF INTERNAL COMBUSTION ENGINES

Internal combustion engines are perhaps the most difficult to lubricate of all known mechanisms, due to the fact that in them the bearings are of differing kinds and speeds, the load is variable, and the same oil, in addition to lubricating the bearings, must serve in the cylinders, where it is subjected to extremely high temperatures.

Lubrication is made necessary by friction. Friction is resistance to relative motion of surfaces in contact and involves loss of power by the rubbing of one body or surface over another. Friction results in the conversion of useful energy into useless heat, accompanied by wear. It can never be entirely eliminated in any mechanism, but by making use of suitable lubricants correctly applied, it can be reduced to a minimum.

All bearing surfaces, however smooth they may appear to the naked eye or touch, are microscopically rough; and wherever two such surfaces come in contact, as on a shaft and a bearing, or a piston and cylinder wall, the roughnesses or depressions on these surfaces will tend to interlock unless kept apart by some lubricant. Even when moving parts are separated by a lubricant, some friction takes place within the liquid itself. This is called "fluid friction." It is very much less than the friction of solids.

Theoretically, it is possible by the use of the correct lubricant to separate entirely the surfaces of a shaft and a bearing, or a piston and a cylinder wall, with a film of lubricant; but, because of the varying load and other factors involved, it is doubtful if such complete separation exists for any noticeable period within an internal combustion engine. The lubrication of such engines involves two distinct types of service. One of these is the prevention of friction, with its ensuing wear and creation of heat in the bearings within the engine. The other is the lubrication of pistons and cylinders, which involves the maintenance of a piston seal that will keep the explosive charge and the burning gases in the combustion chamber above the pistons.

An *ideal lubricating oil for internal combustion engines* should, therefore, have the following qualities:

1. It should have sufficient viscosity (body) to maintain a seal around the piston and cushion the bearings doing the heaviest duty in the engine. If it is too light, the oil will pass the piston-rings too rapidly and will not be capable of resisting the force of explosion or the suction of the intake stroke. If, on the other hand, it is too heavy, it will not be capable of working up around the piston past the lower piston-rings, and the upper part of the cylinder wall will not be sufficiently lubricated.

2. It must be light enough to feed freely into the smallest clearance of the bearings doing lighter duty within the engine.

3. It must have the property called *adhesion;* which means in this case the ability to cling to metal.

4. It must have capillarity or "creeping properties" which will enable it to work into splash—lubricate bearings against the "bearing pressure" therein. Closely allied to this property is that of "spreading" rapidly, which is essential in piston and cylinder lubrication, since at each explosion stroke some of the oil is burned off the upper part of the cylinder and must be replaced instantly by the small amount of oil brought up by the piston on the succeeding stroke.

5. It should retain its lubricating properties when heated even to high temperatures, as on the cylinder walls.

6. It must have sufficient heat resistance not to be unduly thinned out by heat or too rapidly consumed when subjected to extreme heat on the cylinder wall.

7. It should be reasonably fluid even when cold, in order that it may "go into action" promptly when the engine is started.

8. It should be free from any substances that will be "cracked" or broken down if exposed to sudden heat, as when it is splashed on the under side of the heated piston.

9. It should contain no substances that will readily oxidize because of continued exposure to heat and air in the crank-case, since such oxidation results in the deposit of gummy or resinous substances that interfere with satisfactory operation of the motor.

10. It must be of such character that, when it does pass the piston and rings into the combustion chamber in excess amount, it will

vaporize and burn almost completely, and not burn to a tarry residue, forming carbon deposits in the combustion chamber.

11. It must be of such fluidity and viscosity (body) that it can be handled efficiently by the lubricating system incorporated in the engine.

Obviously, there is no lubricating oil that will meet perfectly all of the lubrication demands of internal combustion engines. We can only consider all of the factors involved and then approximate, as nearly as possible, an oil that will be reasonably safe on all points and comparatively free from serious objections. Since all of the desirable qualities are not to be found in any one oil, we must, in selecting the lubricant, be guided by the type of service involved, subject, of course, to the limitations of the lubrication system with which the engine is equipped. It is plain that full-load engines, such as marine engines, racing automobiles, aviation motors, and farm tractors, make excessive demands upon such qualities as heat resistance, piston seal, and the maintenance of lubricating efficiency under hard service. In variable-load engines, such as those in automobiles, greater consideration may be given to such factors as the fluidity of the oil when cold, and the character of the residue when the oil is burned in the combustion chamber.

TYPES OF LUBRICATING SYSTEMS

In so far as the principles involved are concerned, all lubricating systems may be roughly divided into two general groups—"circulating" systems and "all-loss" systems. There are, of course, countless variations in both of these types.

By *all-loss system* is meant a lubricating system in which the oil is fed from an outside source as required. The oil may be fed with the fuel, and thus become mixed with it, or it may be fed from a drip cup into the inlet manifold and then be carried to the cylinders by the explosive charge. This type of all-loss system is rarely found in use. The more frequently encountered type of all-loss systems are those in which the oil is fed by pressure or gravity either directly to the crank-case or through certain principal bearings into the crank-case and never returned to its source. An illustration of one such system is that used in numerous tractors in which the oil is fed by pressure to the main bearings and through them to the connecting-rod bearings and also by pressure to the cylinder walls, the spatter of the excess oil leaking out around the connecting-rod bearings and lubricating the minor parts of the engine.

By *circulating systems* are meant those in which a quantity of oil is filled into the crank-case pump, from which it is circulated and recirculated, either by a force-feed pump or by the fly-wheel, to all parts requiring lubrication. Such circulating systems may be divided into many smaller subdivisions such as full-splash, constant-level circulating splash, force-feed and splash, force-feed, or full force-feed.

Each type of lubricating system has its weaknesses and its virtues. The principal virtue of the all-loss systems is that they supply fresh, undiluted, and uniform oil to the principal working parts. The principal objections to these systems are that they result in excessive oil consumption and that almost without exception they fail to supply sufficient oil to the pistons and cylinders for adequate lubrication and for carrying away heat from the under side of the pistons. They also require very careful attention by the operator.

All circulating systems, however, have a serious weakness in the fact that the lubricating oil in the systems constantly changes while in use. Some of these changes may be considered as follows:

1. The heat and agitation causes some evaporation of the lighter parts of the oil. Such evaporation tends to make the oil more gummy, and is closely allied to oxidation.

2. Most of the heat that is carried away from the piston must be so carried by oil that is splashed or thrown against the under side of the heated piston, there to pick up heat and carry it away to the bottom of the crank-case. If the piston is running extra hot, as in some engines, part of the oil thus thrown against it may, by the sudden and extreme heat, be "scorched" or "cracked." This cracking breaks up the chemical structure of the oil, releasing a black, sooty carbon sediment and hydrogen gas. Usually cracking is the cause of a large part of the sediment found in crank-case oil. (The term *carbon,* as here used, should not be confused with the words "carbon deposit" used in connection with the deposit found in the combustion chamber, since this latter deposit is composed largely of dust baked on the combustion-chamber walls by the heat of the piston, with a binder composed partially of lubricating oil and partially of the heavier parts of the fuel).

3. The oil in the crank-case tends to become *contaminated with dust* and grit that is drawn in through the breather hole, and some of the dust that is drawn in through the carburetor works its way past the pistons into the crank-case oil. Dust and oil make a cutting compound, and dust contamination is one of the serious causes of oil failure in internal combustion engines.

4. Some *moisture* is created in all internal combustion engines. If in doubt about it, hold a cold drinking glass over the exhaust pipe and see how soon the water begins to drip from it. This moisture, in the form of steam, works its way past the piston rings into the crank-case, where it is condensed into liquid form. The water thus formed mixes with the oil, causing it to turn gray in color, and in extreme cases causing foaming. This trouble is naturally worse in cold weather, when the condensation is greater.

5. *Contamination by the fuel* is one of the more serious causes of faulty lubrication. The present design of automobile, tractor, and stationary engines is based upon the theory that they are supplied with a dry explosive mixture of high-test gasoline with air, yet most of these engines are being run on heavier fuels, such as low-test gasoline, kerosene, or distillate, and such heavy fuels enter the combustion chamber as a spray in which only a part is ready to explode, while the balance soaks into the oil film on the cylinder walls and works its way down past the piston-rings into the crank-case. Fuel dilution of the crank-case oil is, of course, closely related to carburetor adjustment, and the dilution becomes worse as the carburetor is set for a richer mixture. Such dilution is also more noticeable in an engine that is started and stopped often than it is in one that is run for long periods under a heavy load. Another factor having a bearing on this dilution is the type of cooling system, which will determine how long it takes for the engine to become thoroughly warmed up after it is started. Faulty ignition will also result in a wet condition of the cylinders which promotes excessive dilution. Such dilution by the fuel will cut the "body" of the oil rapidly and will lower its flash and fire tests, resulting in excessive oil consumption and heavy carbon deposit, and frequently in rendering the oil so unfit for use as to cause serious damage to the engine.

It is an interesting fact that lubricating oil does not wear out! With the exception of the very small percentage of the oil which may be cracked by being splashed against hot surfaces, the remainder of the oil does not change in character except by being contaminated with fuel, water, dust, metal filing, or the like, but until methods are devised for preventing or removing such contamination, frequent crank-case drainage appears to be the only remedy.

Almost all bearings, particularly the bearings of internal combustion engines, must be "worn to a fit." This process is termed "running in" the bearings. During this period the engine will run abnormally hot, and should be carefully watched. The wear is very rapid during the running-in period, but if a correct lubricant is used, this rapid rate of wear should cease when the bearings have been run in to a reasonably good fit.

Experiments with automobile engines have shown that in the variable-load engines, after the running-in process is reasonably completed, 60 to 80 per cent of the wear occurs during the first few moments after the engine is started and before an adequate supply of lubricant is reaching the bearings and cylinder walls. During the "warming-up" period after starting an internal combustion engine, the various moving parts in the engine are gradually expanding because of the heat. The oil for lubricating the engine is cold and sluggish before the engine becomes entirely warmed up. This prevents quick and easy circulation at the time when complete lubrication is most needed. The engine should not be placed under the work load until carefully and thoroughly warmed up to normal running condition.

One rule applicable to all forms of lubrication is that the best lubricant for any mechanism is the lightest oil which will carry the load and maintain a lubricating film around the bearing doing the heaviest duty in the machine. The use of heavier oil than is necessary serves no useful purpose and it should be remembered that there is always a certain amount of fluid friction or "drag" within the oil itself and that this fluid friction becomes greater as the oil used becomes heavier. This fluid-friction loss is more serious than is often realized and frequently amounts to from 5 to 10 per cent of the total potential horse-power of the engine.

A common mistake made in lubricating internal combustion engines is to judge the lubricant by the rate of consumption. As previously stated, the two things to be considered in lubricating an internal combustion engine are the lubrication of the bearings and the lubrication of the cylinders. The rule above stated applies to the bearings and in some degree to the cylinders, but the necessity for maintaining a seal around the pistons sometimes calls for a heavier oil than would be necessary for the bearings only. Operators of internal combustion engines soon learn that if heavier oils are used, the rate of oil consumption is reduced, and they are tempted into using oils which are so heavy that they cannot be safely handled by the lubricating system or do not work their way past the pistons and piston-rings in sufficient quantity to lubricate adequately the upper part of the cylinder walls. The use of extremely heavy oil, therefore, in the effort to reduce oil consumption, may result in excessive wear of the pistons, piston-rings, and upper part of the cylinder wall.

Care should be taken to secure an oil that will have the qualities above described and will be as light in body as can be depended upon to carry the load in the heaviest bearings and, at the same time, maintain a satisfactory piston seal in the engine without excessive oil consumption.

Cooling the cylinder of a gas-engine is necessary in order to hold the temperature down to a point at which the lubricating oil will be able to function properly. A temperature of approximately 170° F. is considered the best. An engine should not be kept too cool or the fuel will not be properly vaporized, nor can the engine operate efficiently.

Maintaining the circulation in the *thermo-syphon system* of cooling depends on the fact that heated water rises. In this type of cooling system, the radiator should be kept nearly full in order that the back pressure of the water will aid in forcing circulation.

The *forced circulation system* uses a pump. As a rule, less volume of water is used and minor obstructions in the system are less apt to stop circulation.

An *air-cooling system* depends on the forcing of air around the cylinders. The cylinders are usually equipped with fans to aid in radiating the heat. The bore of an air-cooled engine is usually small.

The radiator on a tractor which has been operating in fields where trash is present will often become filled with dirt and trash in the opening between the fins and tubes, and overheating will result. The radiator should be cleaned by flushing with a stream of water through the rear of the radiator. A broom may be used to clean fins and tubes as the water is forced through.

Some waters have a tendency to deposit a scale over the entire inner surface of the cooling system. One method of removing this is to fill the system with a solution of one pound of baking soda to four gallons of water. Cover the radiator and run the motor until the solution becomes hot, then drain. Flush the radiator with clean water.

For *hard scale* some authorities recommend a solution of one quart of commercially pure muriatic acid to five gallons of water. Run the motor slowly for a few minutes, then drain the radiator and flush with clean water.

To *guard against freezing* in cold weather, it is advisable to use a non-freezing solution in water-cooled motors. Kerosene should never be used in a thermo-syphon system. The radiator should be thoroughly flushed out in the spring after the non-freezing solution has been drained off. It is a good plan to flush the radiator out once a month in the summer or even oftener if the motor is used to a great extent.

Various substances are used with water in *non-freezing solutions*. Denatured alcohol is most commonly used. Glycerine, when used according to the manufacturers' specifications, is perhaps the best of all from the standpoint of its durability and economy in the long run, as there is no evaporation. The radiator may be drained in the spring and the solution used again the following season.

TROUBLE CHART

Part at fault	*Trouble*	*Effect on motor*	*What to do*
Spark-plug	Loose binding post	No spark	Tighten terminal
	Leak in threads	Poor compression	Tighten or replace plug
	Defective gasket	Poor compression	Tighten or replace gasket
	Cracked insulator	No spark	Replace core
	Points too close	Weak spark	Adjust to thickness of thin dime
	Points too far apart	No spark	Adjust to thickness of thin dime
	Carbon deposit	No spark	Clean plug or replace
	Plug too long	Preignition	Replace with correct plug
	Plug too short	Loss of power	Replace with correct plug
Combustion chamber	Carbon deposit	Preignition and overheating	Scrape out carbon
Valve head	Pitted or warped	Weak compression, irregular firing at low speed, loss of power, and possibly overheating	Grind valve in if possible. May be necessary to reface valve and ream out the seat

Trouble Chart—*Continued*

Part at fault	*Trouble*	*Effect on motor*	*What to do*
Valve stem	Sticking or bent	Irregular firing	Remove valve and clean stem and guide. If bent, straighten stem or replace the valve
Valve-stem clearance	Too little or too much	Weak compression and loss of power; either may result in overheating	Adjust clearance or replace valve
Piston	Carbon deposit	Preignition	Scrape out carbon
	Worn and scored, too much clearance	Weak compression, piston slap, sharp metallic knock at high speed	Replace piston and fit in one of proper size
	Loose wrist-pin bearing	When plug is shorted, has double knock at high speed	Replace bushing, and pin if worn
Cylinder	Walls scored	Weak compression, loss of power	Smooth up. Treatment depends on severity of score
Cam-shaft bearings	Worn or loose	Valve lift short, dull knock in motor	Put in new bushings
Timing gears	Not properly meshed	Valves out of time, loss of power	Time valves properly
	Loose or worn	Distinct knock in region of gears, loss of power	Replace gears if worn
Connecting	Loose crank-pin bearing	Distinct metallic knock when motor runs idle. Shorting the plug decreases the knock	Take up bearing if bushing is not burned out; if bushing is burned out, replace it
Main bearing	Loose or worn	Distinct dull knock when motor is laboring. Shorting the plug on cylinder or cylinders next to the bearing will cut out the knock	Take up the bearing. If bearing is burned out, remove it and install new bearing

TROUBLE CHART—*Continued*

Part at fault	*Trouble*	*Effect on motor*	*What to do*
Carburetor	Too lean mixture	Spitting back in carbureter and overheating	Adjust for richer mixture
	Too rich mixture	Irregular firing, overheating, no power, black smoke from exhaust	Adjust for proper mixture
	Gas level too low in bowl	Motor idles well but will spit and stop when throttle is opened	Adjust float arm so that proper level of gas is maintained
	Gas line nearly plugged or water in carburetor	Continuous spitting and missing, loss of power	Clean gas line, drain carburetor
Radiator	Tubes leak	Overheating due to loss of water	Solder; or, if leak is not large, a good radiator compound may be used as an emergency remedy
	Filled with mud and trash	Overheating of motor	Flush out with hose and work trash loose with a broom
	Coated with scale due to mineral in water used	Overheating of motor	See Page 196
Cylinder-head gaskets	Water leaks into cylinder when motor cools off	Motor will not start. Lubricating oil diluted. Cylinder may be scored	Replace with new gasket (do not use shellac)
	Leaks compression	Loss of power, irregular firing	Replace with new gasket (do not use shellac)

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CHAPTER XIV

FARM BLACKSMITHING

The *forge* in Figure 129 is an agricultural type with hand-operated, gear-driven blower.

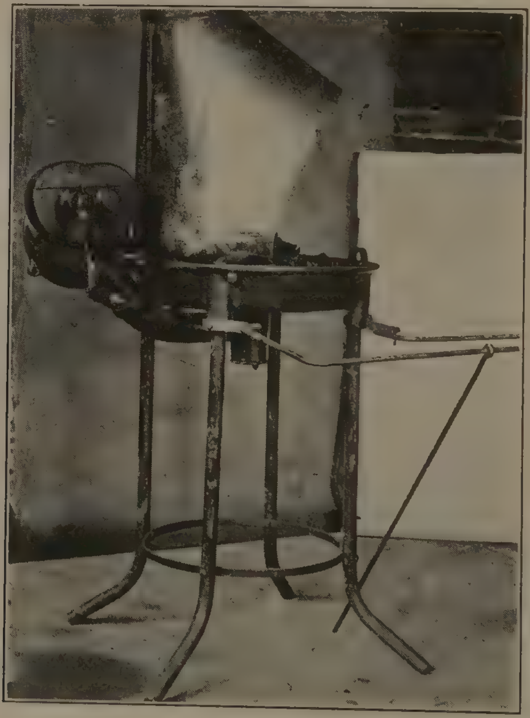


FIG. 129
A forge adapted to farm use.

The *anvil* in Figure 130 has a steel face and horn and is mounted on the end of a block made from a tree trunk. The block should be

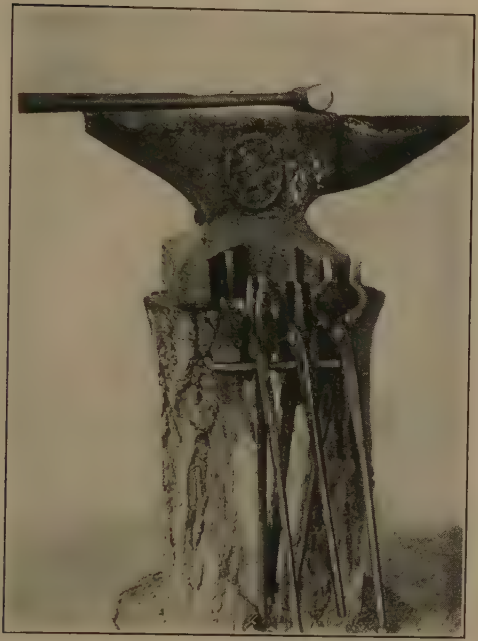


FIG. 130
Anvil and block.

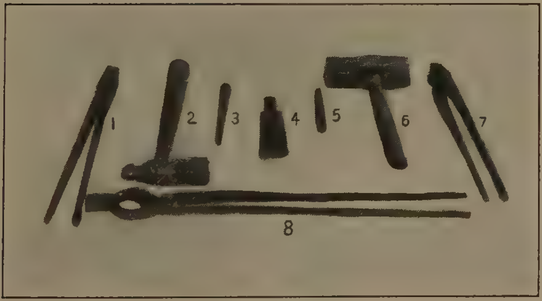


FIG. 131
Small tools necessary for work on the ordinary hot-metal repair jobs on the farm.

about two feet high. The base of the anvil may be cast-iron, wrought-iron, or steel. For ordinary work the weight should be between one hundred and one hundred twenty-five pounds. The anvil should be placed one good pace from the forge with the face at a height at which the clenched hand will swing clear when one stands beside it. The heel should always be placed to the hammer hand as in Figure 130.

In Figure 131 you will note the necessary small tools for doing the ordinary hot metal repair work on the farm: (1) pick-up tongs; (2) ball-peen hammer, weight one and one-half pounds; (3) steel taper punch; (4) hardie on which metal is cut; (5) cold-chisel; (6) cross-peen hammer, weight two pounds; (7) flat-jaw tongs; (8) bolt tongs.

JOB 69

TO BUILD A FIRE IN A FORGE AND USE IT PROPERLY

Material and equipment.

Forge; coke left from previous fire; kindling material (shavings); match; green coal.

Procedure.

1. Clean the tuyère iron (the casting in the bottom of the firebox through which the draft passes) out carefully.
2. Place on it a large handful of shavings.

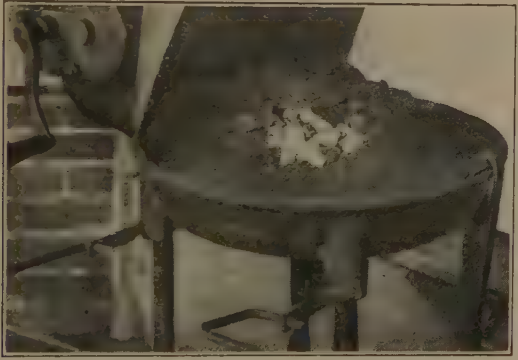


FIG. 132
Kindling the fire in the forge.

3. Rake in the clean coke on the back, sides, and over the top, but leave the front open as in Figure 132.
4. Light the kindling and allow it to burn for a short period before turning on a weak, steady blast.
5. Put a few shovels of green coal around the outer edge of the coke.

By the aid of the drawing in Figure 133—you will note that there are *three distinct areas in a forge fire:* the burning coke in the center where the iron should be placed, a circle just outside of this area where coke is forming from the green coal, and around the outside the green coal, which serves to limit or bank the fire. A strong draft which will provide more oxygen than the fire will use should never be forced through a fire, as the free oxygen will attack the iron or steel and cause excessive scaling. Scaling will also occur when the work is placed too low in the fire.

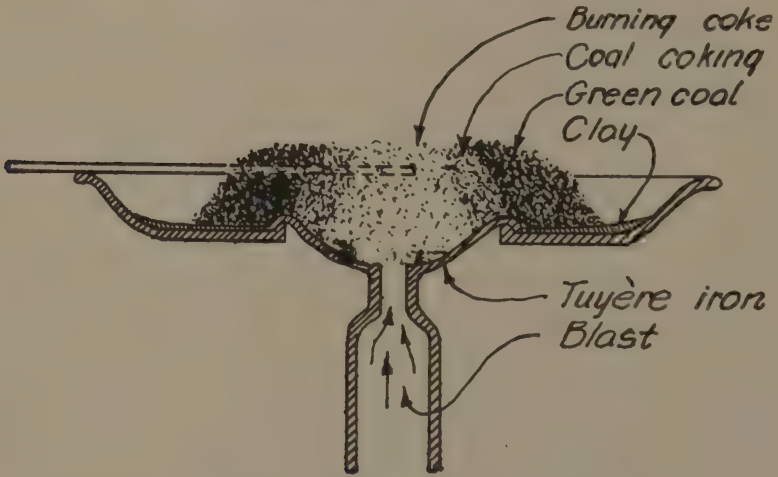


FIG. 133
Three distinct areas of a forge fire.

JOB 70

TO SQUARE A ROUND BAR OF IRON

Material and equipment.

Forge; fuel; match; hammer; anvil; round bar iron ⅜″ by 2′.

General information.

This job involves the principles of the proper use of the hammer, anvil, and forge fire.

Procedure.

1. Grasp the hammer as shown in Figure 134 and swing it with a free, long, and easy stroke. Learn to strike so the face of the hammer falls flat.

2. Heat six inches of one end of the round bar to a pale yellow heat and place it across the anvil, allowing about three inches to extend over the outer edge, as shown in Figure 134.

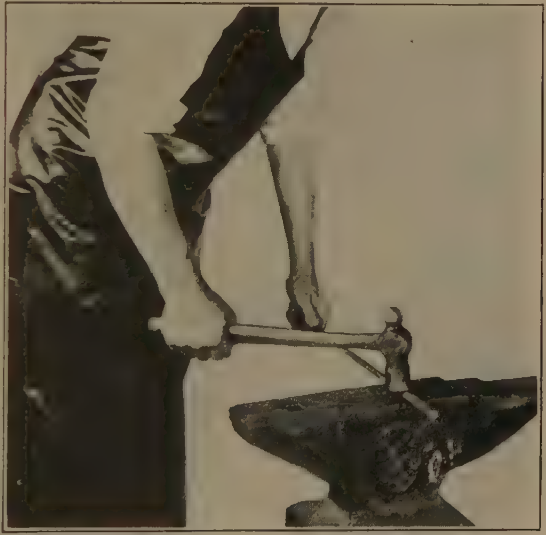


FIG. 134
Proper blow of the hammer.

3. Strike directly over the center of the anvil, drawing the bar back gradually after each blow until it is partially flattened to the tip.

4. Rotate the bar 90° and repeat the previous steps. Always reheat the bar as soon as it becomes a dull red.

5. Begin at the rear of the partially squared portion and finish a distance of three inches by means of well-directed light blows on adjoining sides, drawing it to sharp, even corners.

6. Finish the remaining distance of the bar.

7. To square the end place the bar on the face of the anvil and strike the end of it squarely with the hammer.

8. The end should be of the same thickness as the rear or middle of the forged part.

This act of driving the metal back, or any means by which the diameter of the piece is increased is known as "upsetting." Hammering a piece of metal so as to increase its length is known as "drawing out."

JOB 71

TO FORGE AN EYE ONE INCH IN DIAMETER FROM ROUND STOCK

Material and equipment.

Forge; fuel; match; hammer; anvil; round stock used in Job 70.

General information.

This job involves the principles of constructing or forging eye bolts, eyes for hooks, and eyes for braces.

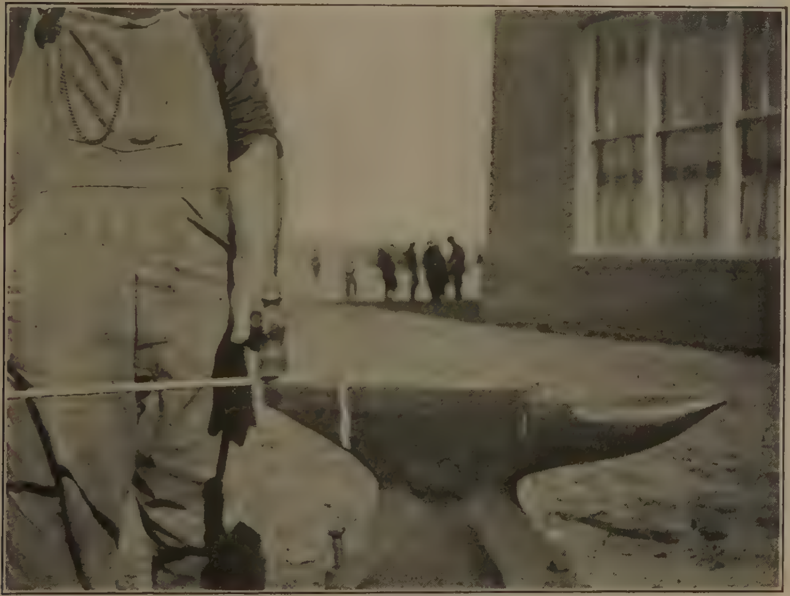


FIG. 135
Measuring the iron bar.

Procedure.

To calculate the amount of stock necessary to make an eye, add the diameter of the stock to the diameter of the desired eye and multiply by three. For example, an eye one-half inch in diameter with one-fourth inch stock would take one-fourth inch plus one-half inch multiplied by three, which equals two and one-fourth inches of stock necessary.

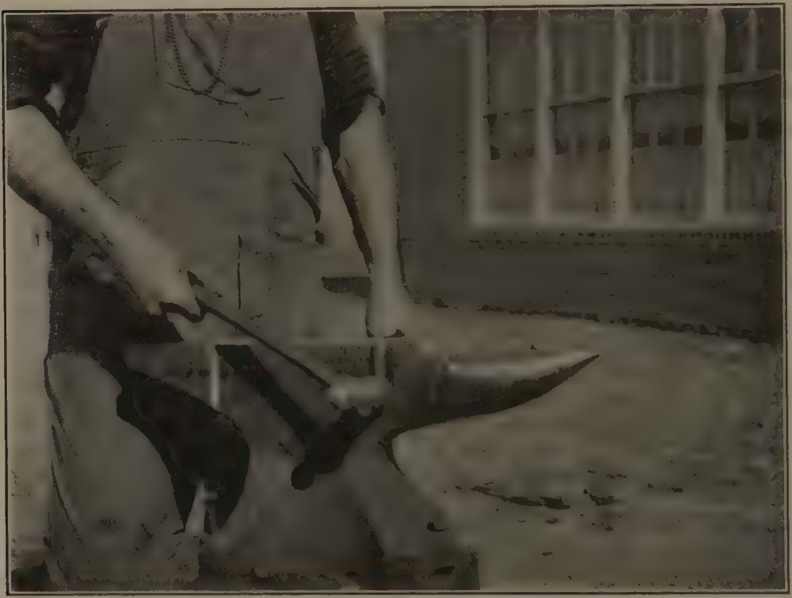


FIG. 136

Bending the rod to an angle of 90°.

1. Calculate the amount of stock necessary to make an eye one inch in diameter.
2. From the heel of the anvil, measuring toward the horn, mark off with chalk the amount of stock required, as in Figure 135.
3. Heat the end of the stock opposite the squared end, and place it on the anvil. Place the edge of the hammer on the bar at the base of the anvil, as shown in Figure 135.

4. Lay the bar across the anvil, the edge of the hammer being placed even with the outer edge of the anvil.

5. Bend the projecting end downward at an angle of 90°, as shown in Figure 136.

6. Reheat the part bent downward and bend it circular over the horn. Start the bending at the tip, as shown in Figure 137, and continue farther back, as in Figure 138, until the eye is nearly formed.

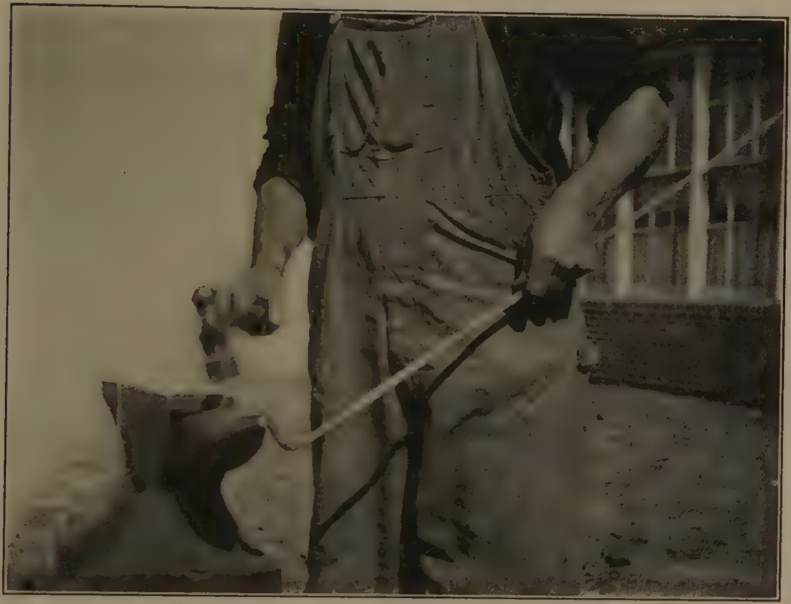


FIG. 137

Begin the bending at the tip.

7. Hold the nearly completed eye over the edge of the anvil. Allowing the base of the eye to rest on the face of the anvil, strike it glancing blows until the eye is closed. Note that the center line of the stock bisects the finished eye as shown in Figure 139.

Suggested practical jobs.

Make eye bolts for the repair of a wagon box, for a hook on a gate, and for gate hinges.

Make eyes on end of braces for hay-rack or other appliances.

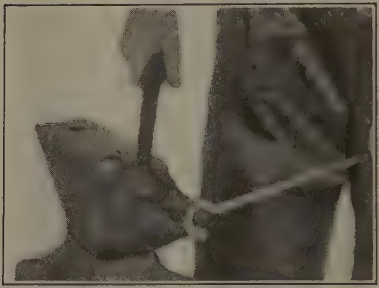


FIG. 138
Forming the eye.

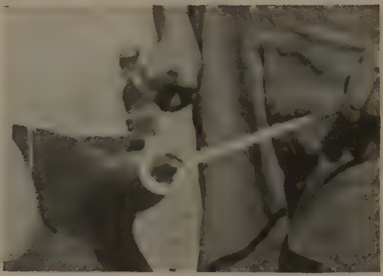


FIG. 139
Completing the eye.

JOB 72

TO MAKE A WELDED LINK, A RING, A ROUND WELD, A FLAT WELD, AND A T-WELD

Material and equipment.

Forge; fuel; match; hammer; anvil; chain tongs; flat-jaw tongs; round stock $\frac{3}{8}''$ or $\frac{7}{16}''$, and $\frac{1}{2}''$.

General information.

These welds are very commonly used in the repair of farm machinery.

The first requirement in welding is a clean fire, free from clinkers and dirt.

Iron passes through certain definite stages when heated. From a dark gray it turns to red, then changes to yellow and then to white. Very soon after this point is reached, sparks are given off. The metal becomes soft and plastic and seems to flow back and forth on the surface. It has then reached welding heat. If two pieces of iron at this heat are brought in contact, they will stick together. A flux is not necessary in welding iron or mild steel, though used by many.

A. Welded Link

Procedure.

1. Heat six inches of the round bar.
2. Lay the heated part across the end of the horn and bend three inches of the heated end downward as in Figure 140.
3. Lay the iron on the face of the anvil and finish bending the "U" as in Figure 141.
4. Reheat the "U." At a place opposite the end of the short leg, cut the stock nearly off on the hardie.

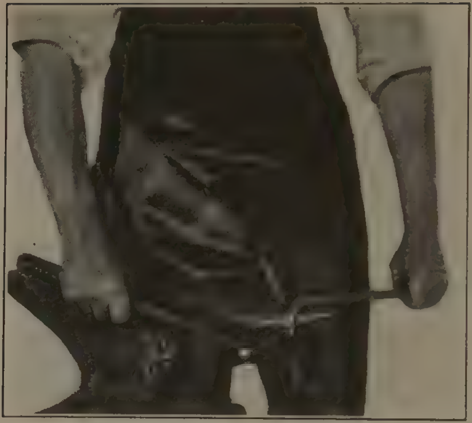


FIG. 140
Beginning the bend.

5. Seize the base of the "U" with the chain tongs and twist it free. Be sure and have the legs of equal length. See Figure 142.

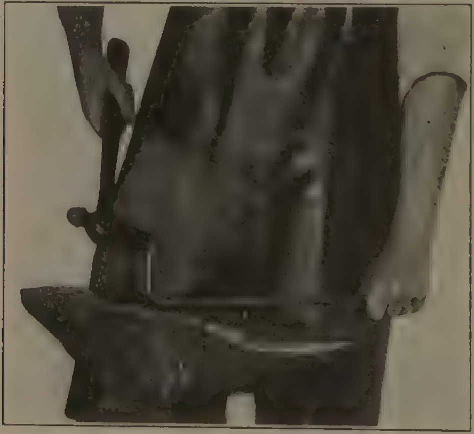


FIG. 141
Completing the "U".

6. Heat the legs to a yellow heat and scarf them as shown in A, Figure 143. In B, Figure 143, you will note several small steps in

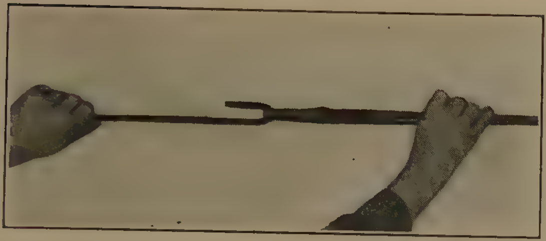


FIG. 142
Twisting the "U" free

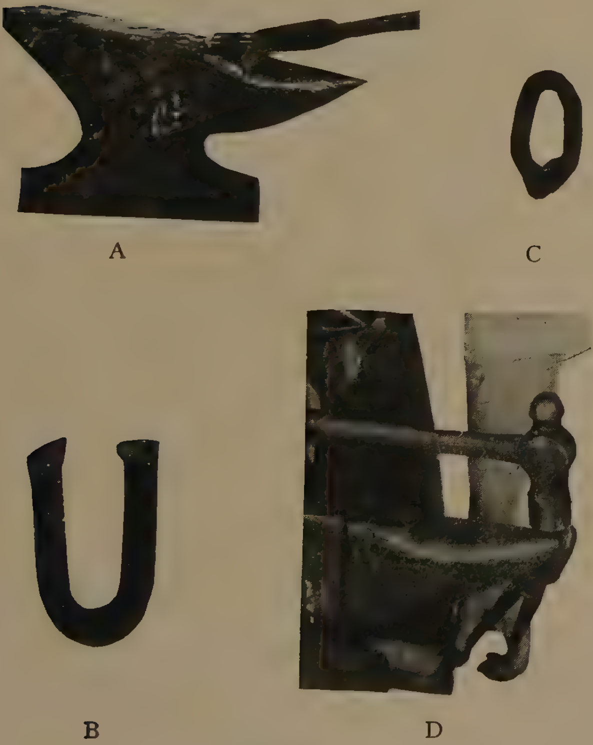


FIG. 143
Welding the link.

the scarf. Each is made by a single blow of the hammer, the leg being shifted farther off the face of the anvil as each blow is delivered.

7. Bend the legs together over the horn of the anvil as shown in C and D, Figure 143.

8. Place the scarfed end in the fire and heat it until the metal begins to flow. Immediately when this heat is reached, withdraw the link and strike it two quick blows on each side of the lap on top of the anvil, thereby welding the edges and points of the laps, and the center.

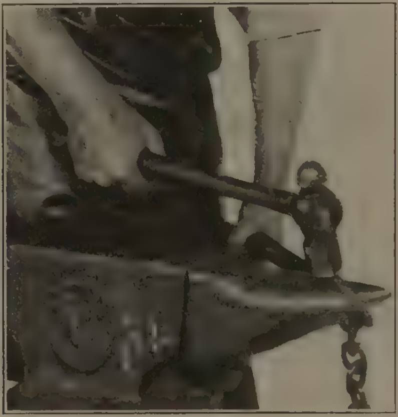


FIG. 144
The welded ring.

9. Reheat the link to a welding heat and finish the welding by working it down on the horn. Do not try to weld when the metal is not flowing. Reheat it.

10. Weld a few single links until you become adept at it.

11. Make another link, but just before closing the "U," slip two welded links that you have already made onto the scarfed link, close it and proceed to weld. Be careful not to burn the welded links.

B. Welded Ring

Procedure.

1. A ring is made very much as a link is, excepting that the "U" is wider and the legs are shorter.

2. After welding the ring, work it round by holding it diagonally across the horn of the anvil as shown in Figure 144.

C. Round Weld

Procedure.

1. Cut two pieces of seven-sixteenths inch round bar mild steel, one two inches long and the other twenty inches long.

2. Upset one end of each of these pieces to a diameter one-third greater than the original size.

3. Scarf the ends to be welded as follows:

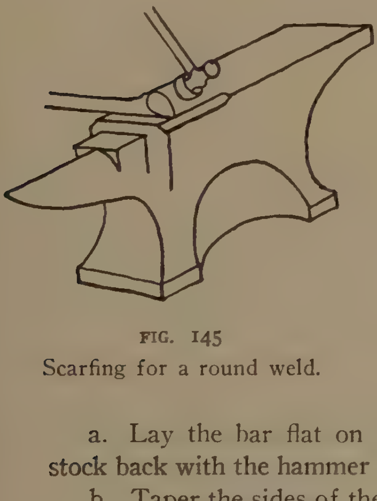


FIG. 145
Scarfing for a round weld.

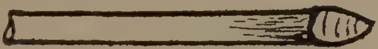


FIG. 146
The scarfed end.

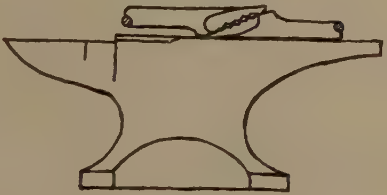


FIG. 147
Putting the scarfed ends together.

a. Lay the bar flat on the face of the anvil and drive the stock back with the hammer as in Figure 145.

b. Taper the sides of the scarf to appear as in Figure 146.

4. Lay the scarfed ends in the fire face down and heat them slowly to insure an even temperature throughout the scarfed area. If one piece should heat faster than the other, draw it back from the center of the fire for a short period.

5. Place the hammer in position on the face of the anvil, peen inward.

6. When the welding heat has been reached, seize the short piece with tongs in the right hand and the longer piece with tongs in the left hand. As the pieces are drawn out, strike them on the edge of the anvil to knock off any clinkers or other foreign material. Lay the short piece on the face of the anvil, scarf up. Rest the long piece on the inner edge of the anvil, then lower the scarfed end down on the other scarf, thereby holding the scarfed surfaces firmly together, as in Figure 147. Let the tongs drop to the floor.

Strike a few sharp blows to stick the pieces together, then strike the tips of the scarfs to weld them together before the metal becomes too cold.

7. Reheat the iron and weld it square.

8. Reheat and weld it round.

9. Draw the bar down to its original diameter; or, if it is already less than its original diameter, upset it until a uniform diameter is secured.

D. Flat Weld

Procedure.

1. Cut two pieces of flat bar of the same lengths as for the round weld.

2. Upset one end of each of the two pieces.

3. Scarf the ends to be welded as follows:

   a. Lay the bar flat on the face of the anvil and drive the upset portion back with blows delivered at a 45° angle.

   b. Taper the sides of the scarf slightly.

4. Weld the pieces together as in the round weld, making sure to weld the tips of the scarfs at the first heat.

5. When the weld is completed, the pieces should be uniform in size throughout.

E. T-Weld

Procedure

1. Cut two pieces of flat bar to the same size as for the flat weld.

2. Upset the middle of the crosspiece to one-fourth larger than its original size.

3. Start the scarf on the crosspiece by resting one edge on the corner of the anvil and striking it from directly above, withdrawing the bar slightly after each blow, which tends to draw out a point.

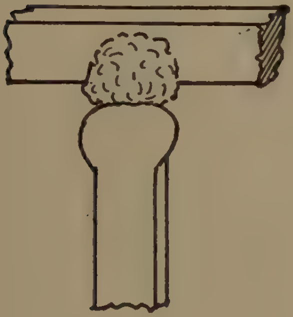


FIG. 148
Making a T-weld.

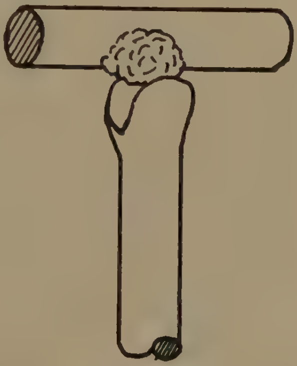


FIG. 149
Making the T-weld with round stock.

Turn the scarfed area up on the anvil and round the scarf out with the peen of the hammer, so that it appears as in Figure 148.

4. Upset one end of the stem and scarf it as in the flat weld, but make it flare out.

5. Weld as in the flat weld.

6. Figure 149 shows the manner of making a round T-weld.

JOB 73

TO FORGE A COLD-CHISEL, PUNCH, SCREW-DRIVER, AND WRECKING BAR

Material and equipment.

Forge; fuel; match; hammer; anvil; hardie; bolt tongs; bucket of water; octagon tool steel ⅝″ or ¾″ for cold-chisels, ⅝″ for punches, ¼″ or 5/16″ for screw-drivers; ⅝″ or ¾″ for wrecking bar; 12″ mill bastard file; 14″ flat bastard file; blacksmith's vise.

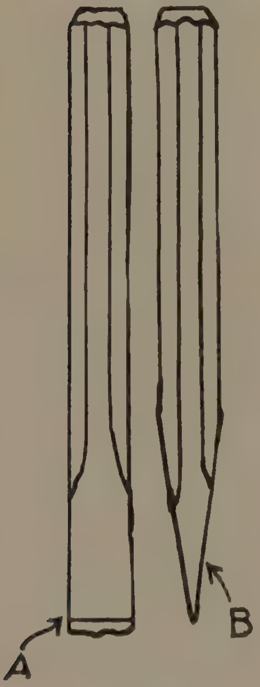


FIG. 150

Cold-chisel. Groove cut at A. B. Taper.

A. Cold-Chisel

Procedure

1. Heat very slowly about four inches of one end of a piece of tool steel to a reddish yellow and forge it down to a true taper as shown at B, Figure 150. Reheat the steel as soon as it loses its reddish color.

2. Reheat the steel to a reddish-yellow color and hold the tip, at a place where it is about one-eighth inch thick, over the outer sharp edge of the anvil at an angle of 30° to the face of the anvil, as shown in Figure 151. Strike the chisel a few sharp blows, causing the sharp edge of the anvil to cut a deep groove across it, as shown at A, Figure 150.

3. Harden the tip by immersing it in cold water up to the place where it was grooved.

4. Lay the chisel across the face of the anvil, placing the groove

even with the outer edge. Strike the tip a light blow with the hammer. A clean break should result.

5. Heat the upper part of the body of the chisel to a reddish yellow and cut it off six inches from the cutting edge, rotating it on the hardie after each blow so as to cut it on all sides equally.

6. Allow the chisel to cool slowly.

7. When it is cool, file the faces to a straight taper. File the sides so that the cutting edge is the same width as the stock itself.

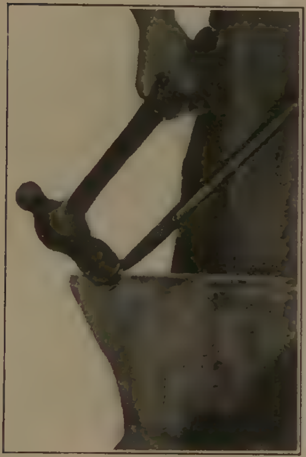


FIG. 151
Position of the bar in cutting the groove.

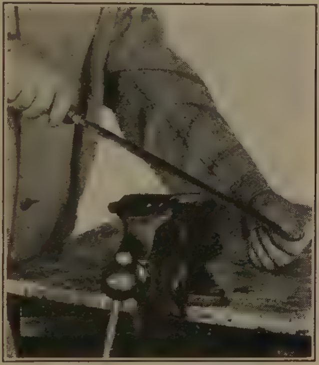


FIG. 152
Filing the cutting edge.

8. Place the chisel in the vise and file the cutting edge as in Figure 152. The angle of the cutting edge should be 60°.

9. Place the chisel well down in the vise and file the head flat. File a 60° bevel one-eighth inch wide around the edge of the head.

B. Punch

Procedure

1. Draw one end of the five-eighths inch tool steel to a square three-sixteenths inch thick on the point and four or five inches long.

2. Forge down the corners, making it an octagonal taper, and

then proceed to forge the taper round. Unless you follow this method, you will experience difficulty in maintaining a straight taper.

3. Cut the punch off so that it will be twice as long as the taper.

4. After the punch is cold, file the head the same as you did the head of the cold-chisel.

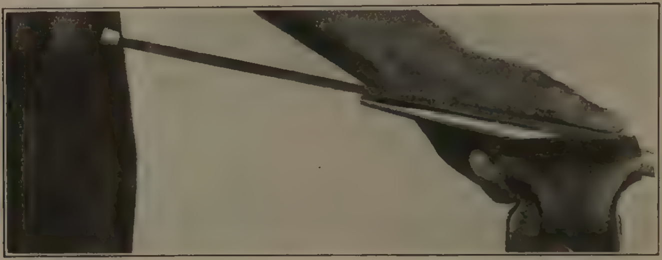


FIG. 153
Filing the tapered end of the punch.

5. File the tapered end of the punch as shown in Figure 153, rotating the punch often to avoid filing it flat in any spot.

6. Temper the punch a dark blue if you desire to have it tempered. The tempering process is described in Job 74.

C. Screw-Driver

Procedure

1. Forge a straight taper on one end of a piece of tool steel. Make it three inches long and one thirty-second inch in thickness at the tip.

2. Allow enough steel for a shank six inches long and enough for an eye one and one-fourth inches in diameter.

3. Follow the same method of making the eye as you did in a previous exercise.

4. File the taper perfectly straight from back to tip. This will tend to prevent the screw-driver from slipping out of the screw slot.

5. Figure 154 shows the finished screw-driver.

6. Temper the screw-driver a dark blue. The process is described in Job 74.

D. Wrecking Bar

Procedure

1. Upset both ends of a three-foot bar of five-eighths inch octagon tool steel a small amount for about two inches from each end.

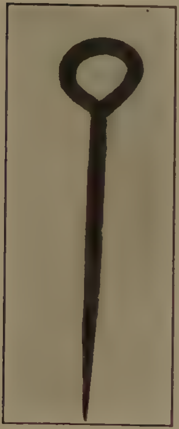


FIG. 154
The completed screw-driver.

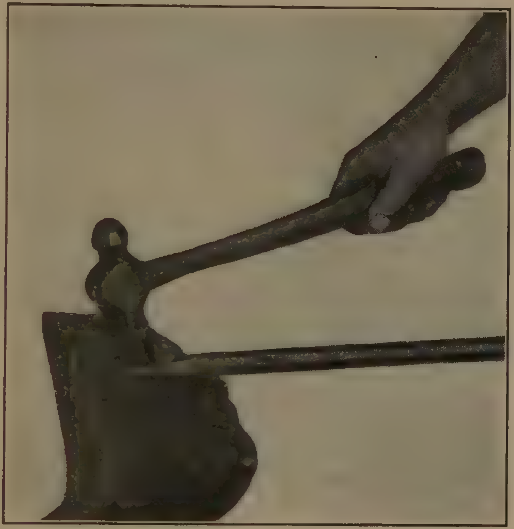


FIG. 155
Drawing out the end of the wrecking bar.

2. Draw one end out to resemble a cold-chisel, as in Figure 155.
3. Draw the other end out similarly, but not quite so far.
4. Heat this end to a red-yellow heat and split two inches of the tip as in Figure 156.
5. Bend the jaws open to permit filing them. They should be filed on a bevel, the bottom having a narrow opening and the top a wide opening to take care of nail heads.
6. Shape the bar so it will appear as in Figure 157.

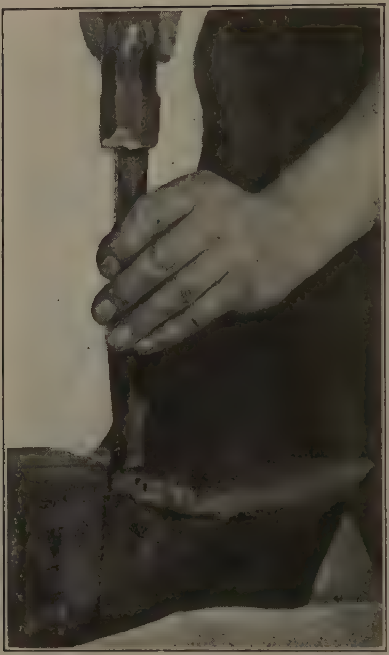


FIG. 156

Splitting the end of the wrecking bar to form the nail claw.

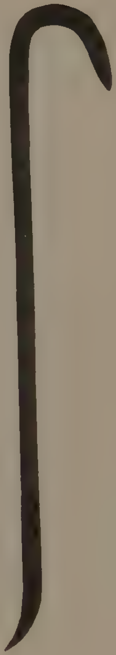


FIG. 157

Wrecking bar completed.

JOB 74

TO TEMPER A COLD-CHISEL

Material and equipment.

Forge; fuel; match; bucket of cold water; rubbing stick, which is made by tacking a piece of emery-cloth over a stick of wood; chisel to be tempered.

Procedure.

1. Place the chisel on top of the forge fire and cover it with a thin blanket of coke. Heat it very slowly to permit the heat to be distributed evenly throughout the chisel.

2. Hold the chisel under the hood occasionally to see how it is heating. When properly heated, four inches of the end should be an even red-yellow in color. In many cases the proper temperature at which to heat a steel will have to be determined by experiments.

3. Dip one inch of the point in the water as shown in Figure 158. Keep the chisel in constant motion to prevent cracking the steel at the water-line. The period of time it is necessary to hold the chisel in the water will depend on the amount of heat in it.

4. Remove the chisel from the water and allow the water to dry off. Then polish one side of it with the rubbing stick and wait for the colors to come down. (As the heat runs down from the body of the chisel, various bands of colors will be noted. These colors are due to the deposits of oxide from the air in varying amounts and kinds as the point grows hotter. These colors will appear as follows:

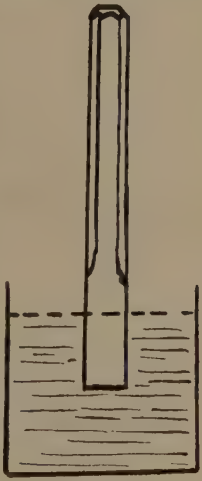


FIG. 158
Hardening the heated chisel.

Light straw, dark straw, brown, light purple, dark purple, light blue, dark blue, and greenish tinge.)

5. As the purple strikes the cutting edge, dip the point in the water.

6. As soon as the water evaporates, dip the point in again. Continue dipping the point to preserve that temper until there is no danger that the heat left in the chisel will anneal the point.

7. After the chisel has become a dark gray or black, there is no danger in immersing the entire chisel in the water.

JOB 75

TO SHARPEN A SOFT-CENTER STEEL SHARE

Material and equipment.

Forge with a clean fire; ball-peen or cross-peen hammer with a slightly rounded face; anvil; flat-jaw tongs; soft-center plowshare.

General information.

Practically all of the *wear on a plowshare* takes place on the under side. Consequently the middle layer of the share, which is low-carbon steel, is left exposed. Therefore, when a share is sharpened, it should be pounded on the upper side, so that the upper layer of high-carbon steel will be worked down over the edge, thereby preserving a hard cutting edge.

Crucible-steel shares may be sharpened in the same manner, but must not be tempered as hard as soft-center shares, because they will become brittle and liable to break.

Chilled shares must be sharpened by grinding on the upper edge until a bevel appears.

Procedure

1. Insert the share in the center of the fire, keeping the share flat. Cover the top of the share with a blanket of coals. Heat slowly to a red-yellow heat, heating only the area that is to be pounded out, as shown in A, Figure 159.
2. When the edge of the share has become hot enough, lay the bottom of the share flat on the face of the anvil and strike it on the upper side, as in B, Figure 159.
3. Reheat the edge of the share as soon as it becomes a dull red.
4. Draw the edge out, making it fairly sharp and as nearly as possible the original shape of the share.

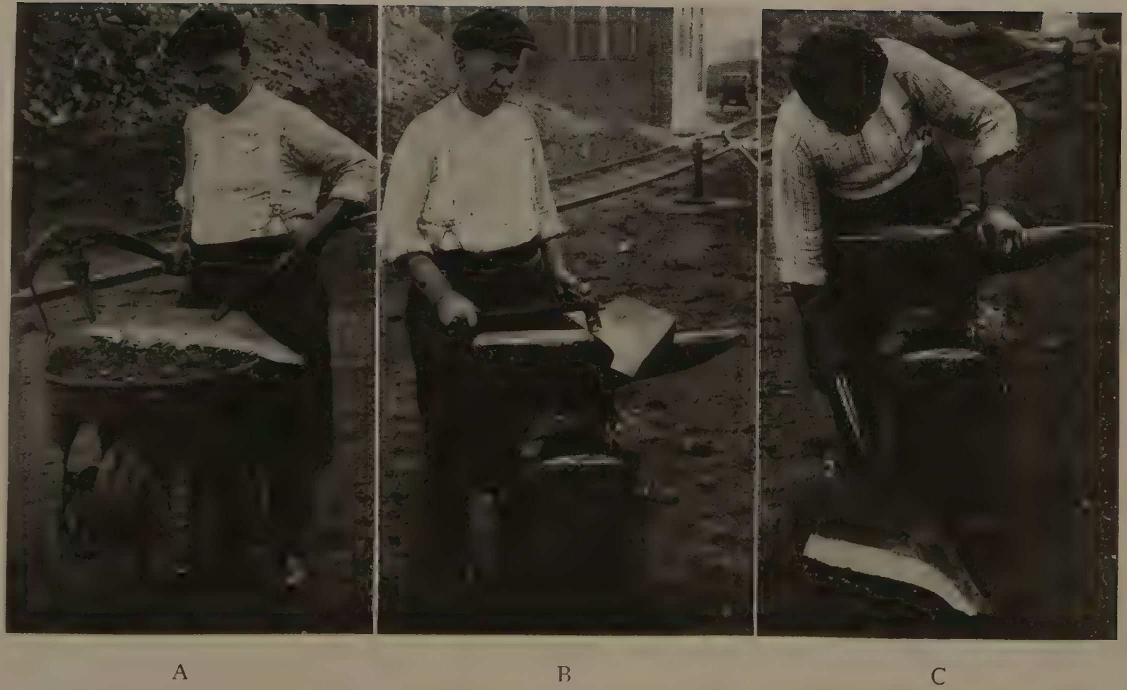


FIG. 159
Sharpening the plowshare. (Courtesy Oliver Chilled Plow Works.)

5. Temper the share as follows:

a. Heat the entire edge to a uniform red-yellow color by drawing it on edge slowly through the fire.

b. Stick the point in the ground deep enough to support the share on edge, as shown in C, Figure 159, and let it cool.

References.

Drew, J. H., *Farm Blacksmithing,* Webb Publishing Co., St. Paul, Minnesota, 1910.

Friese, J. F., *Farm Blacksmithing,* Manual Arts Press, Peoria, Illinois, 1921.

CHAPTER XV

FARM MACHINERY

Carelessness is largely responsible for the inefficient operation of machinery. Every farmer should cultivate the habit of having his machinery working smoothly and efficiently.

System is a fundamental of efficiency. A definite system of checking up and repairing machinery should be adopted. The best time to check up on the repairs and adjustments necessary on a machine is at the close of its operating season. At this time a definite knowledge of the necessary repairs and adjustments is fresh in the operator's mind. If the machine is stored away and no records made, some of the small but vital repairs will no doubt be overlooked when the machine is overhauled two or three months later. Every operator knows that many defects that cannot be detected by a general inspection will show up while the machine is being operated in the field.

The *system of recording repairs* may be that of entering all necessary repairs and adjustments in a shop note-book, or one may make note of all these on a tag, such as a large shipping tag, and attach it to the implement. For example: After the silo has been filled and the ensilage cutter is to be stored away until the next fall, it should be carefully inspected and results noted on the tag as follows: "Main shaft vibrates, bearings loose; knives dull; apron sprocket cracked #123A." Tie the tag to the machine before it is housed. Order the part #123A as soon as possible, so that it will be on hand when you are ready to repair the ensilage cutter. Parts for machines should be ordered by number. If you are unable to secure the number, describe the part. Note where it goes, giving the name and number of the machine and the year it was purchased.

Drills may be classified in two different ways according to (1) the furrow openers, and (2) their method of feed.

The *single-disc furrow opener,* Figure 160, has the greatest penetration and will work very well in trashy or hard ground, but clogs more readily than other types in wet ground. The construction and parts are shown in Figure 161.

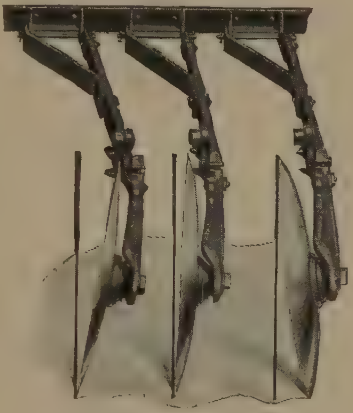


FIG. 160

Single-disc furrow openers are adjustable. Correct undercut is shown by the middle disc. (Courtesy International Harvester Company.)

The *double-disc furrow opener* does not have the penetration of the single disc, but works well in trashy ground and does not clog readily in wet ground. See Figures 162 and 163.

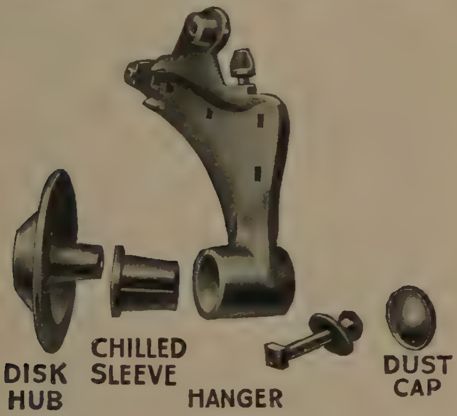


FIG. 161

Detailed view of single-disc chilled bearings. (Courtesy International Harvester Company.)

The hoe furrow opener, shown in Figure 164, has very good penetration when properly set, and does considerable cultivation, but does not deposit the grain at as uniform a depth as the others, and clogs in trashy land or sod land.

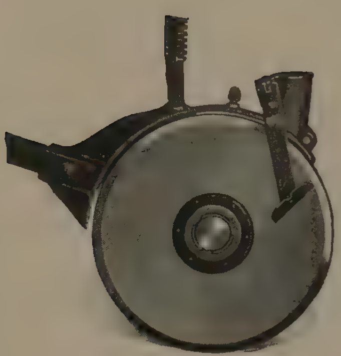


FIG. 162

Saw-blade double-disc furrow opener. (Courtesy International Harvester Company.)

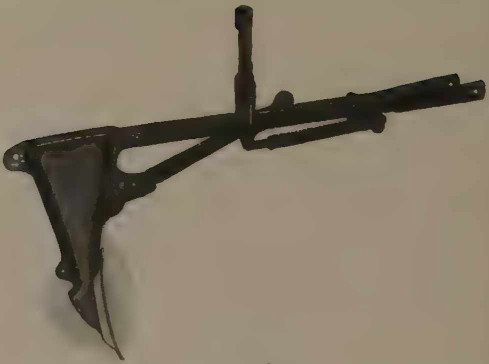


FIG. 164

Pressed-steel spring-hoe furrow opener, much used in sections where stones and roots abound. (Courtesy International Harvester Company.)

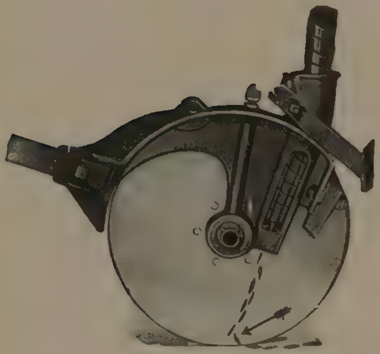


FIG. 163

Interior view of the saw-blade double disc. (Courtesy International Harvester Company.)

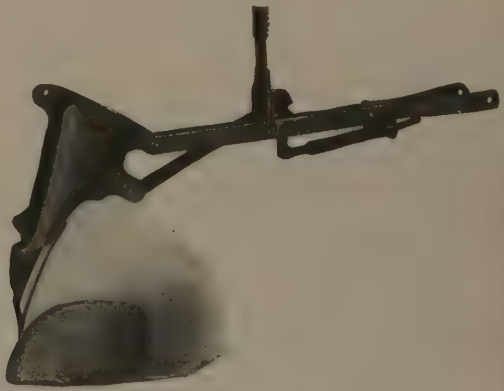


FIG. 165

Should a spring hoe strike an obstruction, it will bend backward until the hard spot is passed, when it will automatically return to working position. (Courtesy International Harvester Company.)

The hoe does not have the penetration of the disc types, and does not operate quite as successfully under trashy conditions. It is very successful in stony land and where roots abound, as is evident from Figure 165.

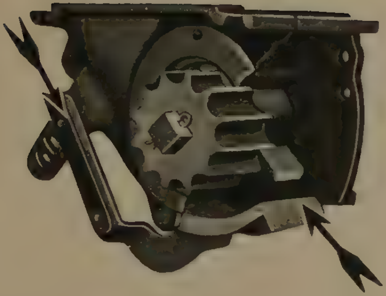


FIG. 166

Sectional view of throat fluted feed showing the throat open wide for sowing beans and the like. (Courtesy International Harvester Company.)

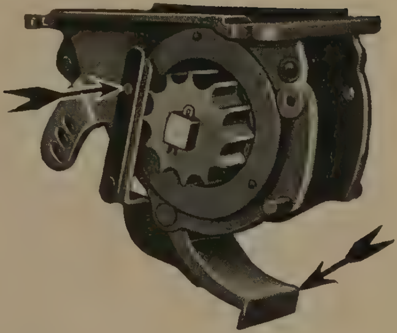


FIG. 168

Complete fluted feed cup with adjustable throat dropped for removing seed and cleaning. (Courtesy International Harvester Company.)

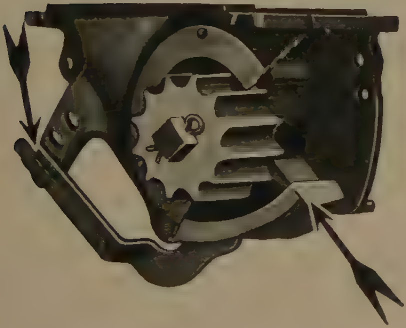


FIG. 167

Sectional view of throat fluted feed showing throat in middle position for fairly large seeds. (Courtesy International Harvester Company.)

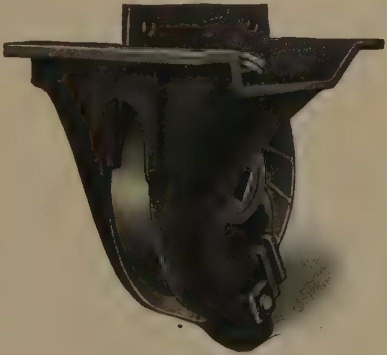


FIG. 169

Internal or double-run feed cup and wheel. One side of the cup is for large seeds, the other side for small seeds. (Courtesy International Harvester Company.)

There are two types of feeds:

1. The *fluted feed* consists of a fluted cylinder in which the amount of exposure of the fluted shell determines the degree of feed. See Figures 166, 167, and 168.

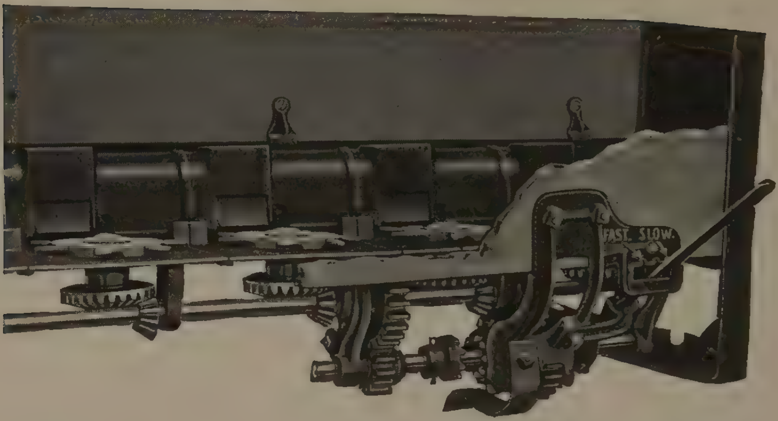


FIG. 170

Fertilizer feed on a fertilizer drill. (Courtesy International Harvester Company.)

2. The *internal force feed* (see Figure 169) is very satisfactory for the larger grains or seeds such as peas, oats, or beans, but is not as accurate as the fluted feed for the smaller grains.

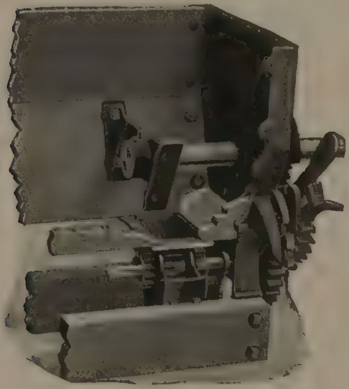


FIG. 171

Reversible axles used in a broadcast seeder. (Courtesy International Harvester Company.)

In *selecting a drill,* one should take into consideration the field conditions, and from these determine the type of furrow openers required. One should consider carefully the strength of the frame, the trussing of the seed box, the type of delivery, the boot, the construction of materials of the bearings, dust exclusion, and the manner of oiling.

There are various styles of *fertilizer attachments* (see Figure 170), which fit on to the back of the seed box. By means of adjustable devices in the attachment, a certain amount of fertilizer is fed into the seed tube and is deposited with the seed in the furrow.

Grass-seeding attachments are also made for each drill. The feed is usually of the fluted-wheel type. The grass seed is fed directly into the seed tube or it is delivered in front or behind the furrow openers.

Broadcast seeders are also popular in rough, stony land or stumpy places. Some of them are equipped with reversible axles, as shown in Figure 171. When the axles are reversible, they can be turned end for end when worn, and thus provide for increasing the life of the machine.

JOB 76

TO PREPARE THE GRAIN DRILL FOR THE REGULAR WORK

Material and equipment.

Eight-inch monkey-wrench; screw-driver; hammer; oil-cans, one filled with kerosene and one with good-quality machine oil; can of cup grease; pliers; cold-chisel; punch; wagon jack.

Procedure

1. If the grain was not all removed the previous year, clean it out thoroughly. Remove the grain tubes. The method of cleaning will depend on the drill. On some drills it is possible to open a feed gate at the rear of the feed shell, which greatly facilitates the cleaning operation. On all models, open the feed wide before commencing to clean out the grain.

2. Clean out any obstructions in the grain tubes or boots.

3. Inspect the spacing of the furrow openers and make the necessary adjustments. If the braces are bent, they may be pried back into place. If badly bent, it may be advisable to remove them and straighten them in the farm shop.

4. Inspect the discs carefully. It is advisable to take the discs apart, clean the bearings in kerosene and then reassemble them and pack them well with cup grease. Any badly worn bearings should be replaced.

5. Adjust the scrapers so that they fit up against the discs closely enough to clean them of all mud or trash, but not so close as to interfere with their rotation.

6. Apply kerosene to every bearing. After the kerosene has soaked in well, jack up one wheel, throw the clutch in, and apply pressure very lightly in rotating the wheel. If there is resistance, the feed shaft is probably sticking because of rust in the bearings or other obstruction in the feed cup. Locate the trouble and remedy

it, as the obstruction may bring about a twisted feed shaft which will cut on the bearings.

7. Examine the eveners. Hitch and replace any worn or broken parts.

8. Tighten any loose nuts and replace any badly worn bolts.

9. If necessary, paint the machine. Directions for painting machinery are given in Chapter II.

10. Grease and oil thoroughly. Fill the grease cups ready for use.

GUIDE IN SELECTION OF A GRAIN DRILL

1. Kind of drill (single-disc or double-disc, shoe, or hoe)?
2. Is machine made by a reliable manufacturer?
3. Is the seed box substantially made and trussed?
4. Is the frame substantial?
5. What type of bearings has the main axle?
6. Is the seed shaft chain-driven or gear-driven?
7. What type of feed shell is employed?
8. How is the feed regulated?
9. What type of seed tube is used?
10. a. Are the furrow openers staggered?
    b. How many furrow openers are there?
    c. What is the distance between the furrow openers?
    d. Can the spacing be adjusted conveniently when necessary?
    e. Where are the furrow openers placed in relation to the main axle?
    f. If disc, of what materials are the bearings made?
    g. Can the bearings be lubricated easily?
    h. Is there an efficient device employed to exclude dirt from the bearings?

CORN PLANTERS

Corn planters differ as to type of drop and furrow openers. As regards wheels, the open types have been adopted for practically all of the planters on the market at the present time.

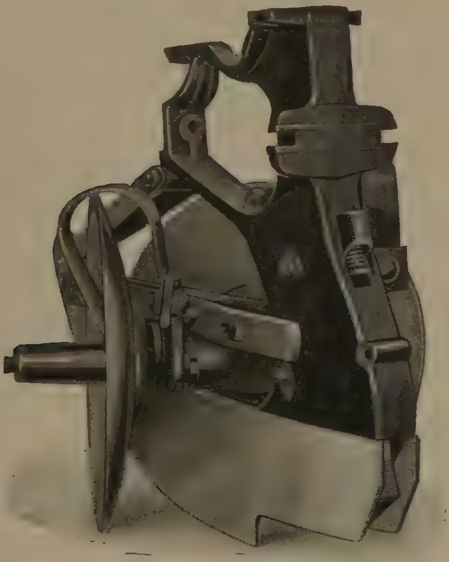


FIG. 172

Back view of double-disc furrow opener. The polished steel shoe opens the trench and the sixteen-inch disc blades rout out the furrow. (Courtesy International Harvester Company.)

On the later makes of planters the shoe and disc are interchangeable. The *disc planter* will operate much more satisfactorily than the shoe in hard, trashy, or soddy land, because it has better penetration. The disc furrow opener is shown in Figure 172. It has slightly less draft. In well-prepared soil, the *shoe planter* will run more steadily and give less variation in the depth of planting. See Figure 173.

The *double-disc type* of opener resembles somewhat the action of the shoe. It works better on sod and in trashy ground because of its better penetration.

The two general types of drop are the hill-drop and the accumulative type.

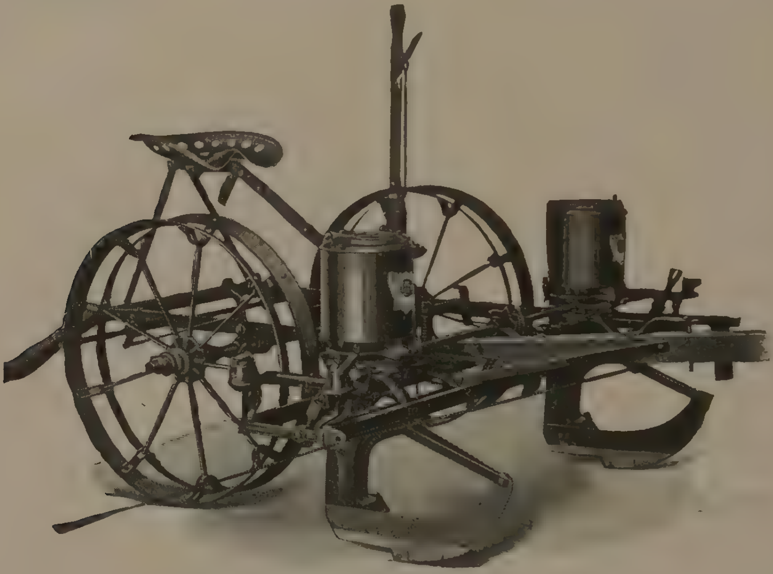


FIG. 173

Corn planter with shoe furrow openers. (Courtesy International Harvester Company.)

In the *full hill-drop*, the seed plate is provided with a hole large enough to contain the desired number of kernels for one hill. If the kernels should vary slightly in size, an extra kernel could slip into the plate opening. Thus the drop would tend to vary unless the seed is carefully graded. One opening in the seed plate passes over the delivery-boot opening every time the planter is tripped. In the hill-drop type, the strain of rotating the seed plate and of opening the valves all comes on the wire. This tends to wear the wire and forks rather rapidly.

In the *accumulative type* of drop (see Figure 174), the seed cells are large enough to contain only one kernel at a time. A number of cells corresponding to the desired number of kernels per hill passes over the delivery boot between each trip of the valves. The plate is actuated by a transmission driven from the main axle. For example: if three kernels in a hill are desired, the plate is driven at such a speed that three seed cells will pass over the delivery boot from the time one hill is dropped until the next is dropped. To vary the number of kernels per hill, the speed at which the plate is driven is varied. The accumulative type of drop may be of either edge or flat selection. In the flat selection, the kernels lie flat and the cells are just large enough to contain one kernel at a time. In the edge selection, the kernel lies on its edge in a cell on the outer circumference of the plate. With the accumulative type of drop, the only strain put on the wire is that of opening the valves.

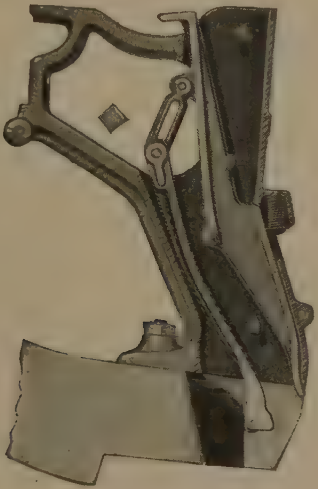


FIG. 174

Valve action of the dropping mechanism of the corn planter. (Courtesy International Harvester Company.)

JOB 77

TO PREPARE THE CORN PLANTER FOR ITS REGULAR WORK

Material and equipment.

Eight-inch monkey-wrench; screw-driver; hammer; oil-cans, one filled with kerosene and one with good-quality machine oil; can of cup grease; pliers; cold-chisel; punch; wagon jack.

Procedure

1. Remove the hopper and plates. Any broken or defective parts should be replaced.
2. Remove any old seed or foreign materials in the delivery boots.
3. Apply kerosene to all bearings.
4. Test the action of the valves. See that they act freely.
5. Examine the ratchets, making sure that they are not badly worn and that the springs have sufficient tension.
6. Check the distance between the furrow openers. Is the marker set properly for the desired width of planting?
7. Inspect the disc bearings for wear and adjustment. If the bearings are badly worn they should be replaced.
8. Inspect the scrapers on the discs and make the proper adjustments.
9. After all bearings have had a liberal application of kerosene, jack up the wheels and test the checking and drilling mechanism.
10. Replace any worn links in the chain or any gears worn enough to make their proper functioning at all doubtful.
11. Tighten up all nuts.
12. If necessary, paint the machine.
13. Grease and oil thoroughly all of the wearing parts.

GUIDE FOR THE SELECTION OF CORN PLANTERS

1. Kind of planter (horse or tractor)?
2. Is the planter made by a reliable manufacturer?
3. For what width of rows can the planter be adjusted?
4. What provision is made for leveling the check head:
    a. Crosswise?
    b. Lengthwise?
5. What kind of furrow openers (shoe, stub, single-disc, or double-disc)?
6. What type of wheel is employed (solid, open, or double)?
7. Does the strain of actuating the dropping mechanism come on the wire, or is it driven from the main axle?
8. Is it a cumulative-drop or hill-drop?
9. Is it flat-selection or edge-selection?
10. Is it sight-feed?
11. Does the shank have one or two valves?
12. Can the drop be changed while the planter is in motion?
13. Can the plates be changed without emptying the hoppers?
14. Can adjustment for drilling be easily made?
15. What is the method of rewinding the wire?

A large percentage of the mowers discarded on farms to-day could, if a few simple repairs and adjustments were attended to, be made to serve satisfactorily for several years more.

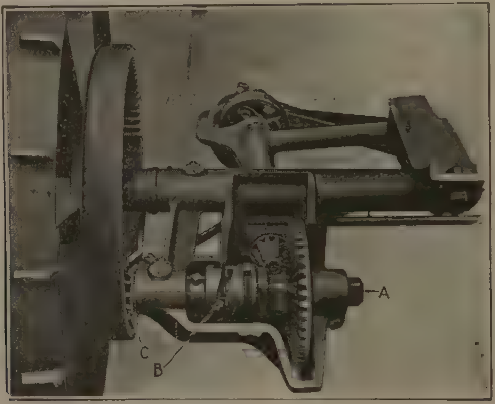


FIG. 175

(A) Adjustment to keep gears properly meshed. (B) Clutch. (C) Internal gear drive. (Courtesy International Harvester Company.)

The *gear-driven mower* has given the best satisfaction, chiefly because gears are more positive in action and are more durable. See Figure 175. Figures 176 and 177 show two types of gear-driven mechanisms.

The advantage claimed for the internal over the external gear is that there are more teeth in the mesh, and consequently there is less strain on any individual tooth. In addition, there is a tendency to draw the small spur-gear inward. This tendency is counteracted by the action of the beveled gears, which are continually forcing each other apart. The tendency of the pitman wheel on the sloping crank-shaft is to draw down or to cause an end thrust. In Figure 176 the arrangement of the bevel gears tends to increase this end thrust. With this type of mower, a ball-thrust bearing is provided. On some others of this type, hardened steel washers are employed. The wearing of this thrust bearing will allow the bevel gears to come out of full mesh, thereby increasing the draft. In Figure 177, the beveled gears are placed in front of the axle. The thrust caused by the pitman wheel is counteracted by the tendency of the beveled gears to separate. Accordingly, no thrust bearing is necessary in this type of mower.

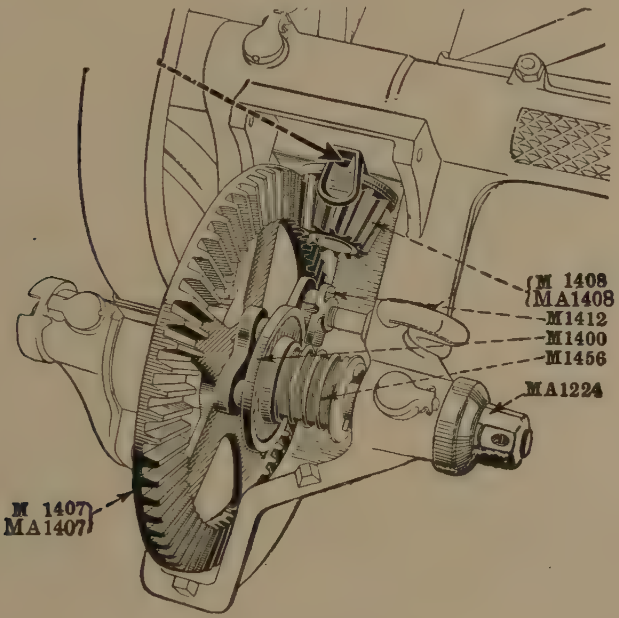


FIG. 176

Type of gear-driven mower. (Courtesy International Harvester Company.)

The *bearings* of the secondary shaft are very important, and a means of taking up the wear between the bevel gears should be provided. Such a device is shown in Figure 175.

Solid bearings are provided for the crankshaft. These bearings consist of a brass or babbitt bushing which can be replaced when badly worn. Unnecessary play due to wearing of the crank-pin bearing and ball-and-socket joints puts undue strain on the other parts of the machine. The weight of the cutter bar should be supported by the main frame.

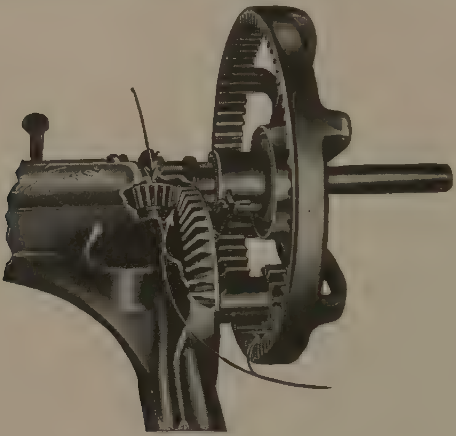


FIG. 177

Type of gear-driven mower. (Courtesy John Deere and Company.)

JOB 78

TO PREPARE THE MOWER FOR ITS REGULAR WORK

Material and equipment.

Eight-inch monkey-wrench; screw-driver; hammer; oil-cans, one filled with kerosene and one with good-quality machine oil; can of cup grease; pliers; cold-chisel; punch; wagon jack.

Procedure.

1. Remove the sickle or knife. Grind all of the good sections, leaving any broken or badly worn sections to be replaced after the grinding operation is finished. See Job 40.

If the ball on the sickle head has become worn flat or elliptical, it is advisable to replace the sickle head. Great care should be taken in performing this operation to see that the rivets do not buckle, but fill the entire hole, and that the head fits snugly and true.

2. Adjust the openings of the guard wings and align the guards by striking them with the hammer. If a guard should come up too high in being replaced, insert shims between the guard and the bar to secure the proper alignment. If the ledger plates have become worn, they should be replaced. Sharpen the points of the guards with a mill file. Do not remove the guards unless necessary as it is sometimes difficult to get them perfectly tight again.

3. Examine the swath board and stick. It should fit snugly to insure the proper turn of the swath.

4. Examine the pitman. If the socket has become elongated, it should be replaced. If the wrist-pin bearing has become badly worn, it should be taken up. If it is not adjustable, it should be replaced. The wrist-pin should fit tightly in the pitman wheel.

5. When the sickle and bearings have been repaired, install the sickle in the bar. Place the pitman in out-center. Each section should center on a guard. A bar which is threaded is pro-

vided in front or back of the pitman. By means of this the cutter bar may be adjusted in or out.

The cutter bar should also be so adjusted that the outer end will lead the inner end by approximately one and one-fourth inches on a five-foot bar, as shown in Figure 178. This slight lead takes care of any looseness in the cutter-bar assembly so that the bar will run true when the mower is in operation.

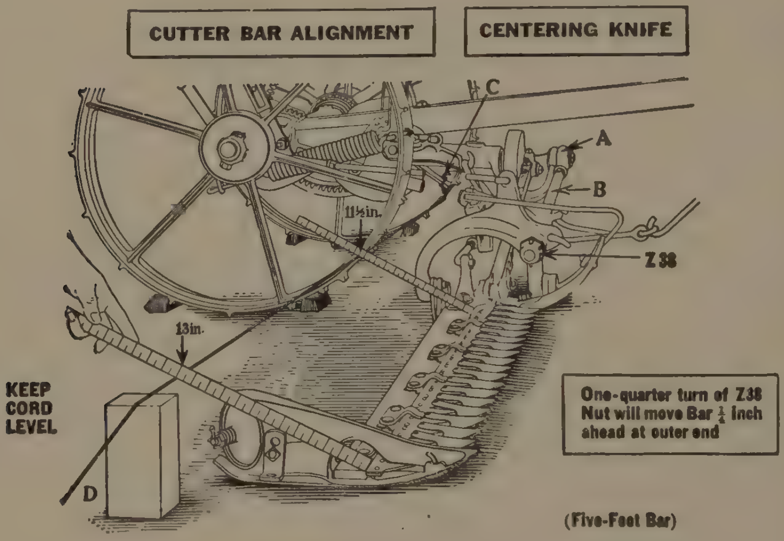


FIG. 178

Adjustment of cutter bar. (Courtesy John Deere and Company.)

Examine the bearing of the sections on the ledger plates. If the tip of the sections does not touch, it will probably be necessary to adjust or replace the wearing plates. In general, the sickle should fit snugly but move freely in the cutter bar.

6. Examine the gears. They should be in full mesh. On some machines a device is provided for taking up the wear of the gears. If no such device is provided, new bearings will probably have to be installed. On some machines the end thrust of the crankshaft is very great, due to the fact that the large end of the small bevel-gear pinion is down. In this type of machine, thrust bear-

ings are usually provided. In types in which the large end of this pinion is up, the thrust is counteracted. If the crank-shaft bearings are worn, they should be replaced, since no adjustment is provided.

7. If the drive wheels have excessive end play, this should be taken up by means of the adjustable collar on the outside of each wheel.

8. Inspect the pawls to see that there are none broken or worn. See that the springs are in good condition.

9. Oil all bearings well before starting the mower.

10. If necessary, paint the machine.

GUIDE IN SELECTION OF MOWERS

1. Kind of mower (horse or tractor)?
2. Is the machine made by a reliable manufacturer?
3. Width of cut?
4. What kind of bearings has the main axle?
5. Type of drive gear (internal or bevel)?
6. How is the end thrust of the crank-shaft taken care of?
7. How are the wear and thrust of the bevel gears taken care of?
8. What is the type of the lift?
9. a. By what means is the cutter bar lined up?
   b. By what means is the sickle timed?
   c. How is the cutter bar tilted?
   d. What type of ledger plate is employed?
   e. Does the cutter bar have wearing plates?
10. a. Is the pitman iron or wood?
   b. Can it be adjusted for wear at the sickle end?
   c. Can the crank-pin bearing be taken up when worn?
11. a. What kind of bearing has the crank-shaft at the lower end?
   b. Can the bearing be replaced easily?

The operator of the binder should be thoroughly familiar with the necessary operating adjustments and the means of properly lubricating the moving parts of his machine.

The *platform* of a binder should always be tilted slightly downward in front, as it takes the grain better in that position. The *cutter bar* should be adjusted level at a height to suit the greater portion of the grain in the field. See Figure 179. By means of the *tilting lever,* the short or lodged grain can be picked up. There usually is provided a strip of strap iron which fastens to the outer end of the platform and rests on the canvas the full length of the platform on which the heads should fall. This strap has a retarding action on the heads, which, being heavier than the straw, tend to cling to the apron and travel faster, thereby causing them to go into the elevator lengthwise. The *aprons* should be just tight enough to operate without slipping. In case a large amount of millet or flax is to be cut, a strip of canvas two feet wide tacked on the lower edge of the apron has been found to work very successfully.

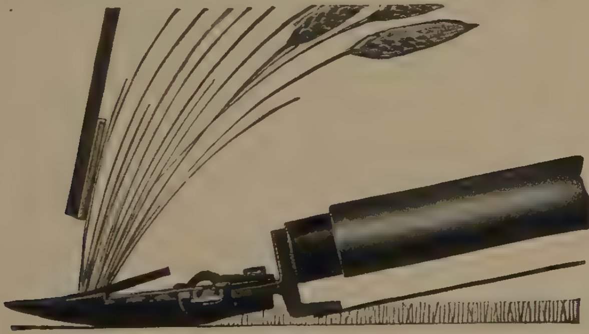


FIG. 179

The platform and reel can be adjusted to cut either tall or short grain. (Courtesy International Harvester Company.)

The *reel* should not sag on the outer end, as there is danger that it will catch in the cutter bar when low adjustments are made. The purpose of the reel is to deliver the grain to the platform in proper shape. In grain that stands straight, the reel should strike the grain a few inches below the heads and bend it back slightly just as it is being cut off. See Figure 180. Running the reel too low will cause the grain to be picked up and thrown too far back on the platform, resulting in a ragged bundle. Improper adjustment of the reel is sure to result in poor bundles. The windboard at the rear of the platform should be adjusted far enough back so that, when the reel is working properly, no grain touches it at any time.

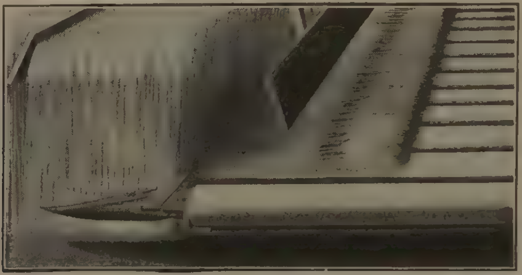


FIG. 180

The reel guides the grain to the cutter. The canvas is only ¾" above and 1⅝" back of the knife. (Courtesy International Harvester Company.)

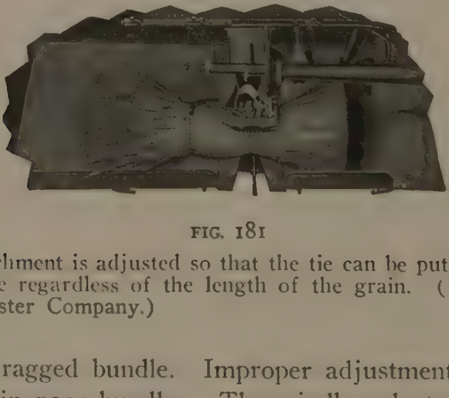


FIG. 181

The binding attachment is adjusted so that the tie can be put about the middle of the bundle regardless of the length of the grain. (Courtesy International Harvester Company.)

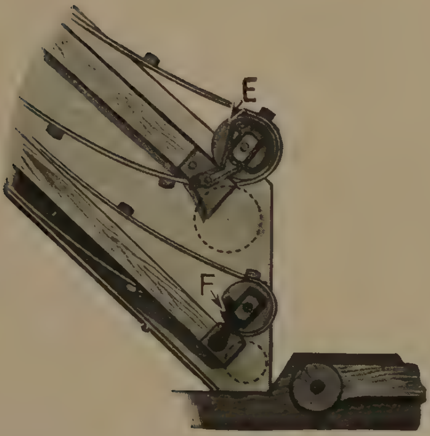


FIG. 182

The rollers E and F are hinged, which makes it possible to tighten or loosen the canvas with ease. (Courtesy International Harvester Company.)

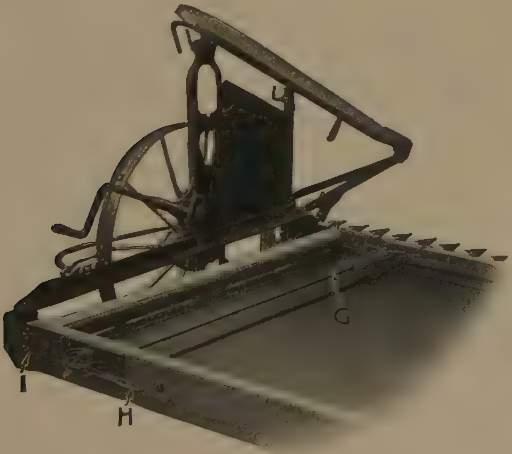


FIG. 183

Platform canvas tightener, G to loosen canvas, move lever H to position I. (Courtesy International Harvester Company.)

If the *elevator canvas* begins to creep, that is, if one side runs ahead of the other, it is evident that the elevator frames are not square. They should be squared up at once or broken slats will result.

The *butter* should be adjusted to operate at right angles to the length of the straws. See Figure 181. It should not be necessary to draw the butter in except in very short grain, or to force it out except in exceedingly long grain. The binder should be adjusted forward and backward to bind the varying lengths of grain properly.

When the binder is not in operation, the aprons should all be loosened. Devices for quickly loosening the aprons are provided on all of the modern machines. See Figures 182 and 183. The canvases should not be allowed to get wet at any time.

The *knotter head* is responsible for practically all of the serious difficulties experienced in operating a binder.

JOB 79

TO MAKE THE NECESSARY ADJUSTMENTS AND REPAIRS ON THE GRAIN BINDER

Material and equipment.

Eight-inch monkey-wrench; screw-driver; hammer; oil-cans, one filled with kerosene and one with good quality machine oil; can of cup grease; pliers; cold-chisel; punch; wagon jack.

Procedure.

1. Inspect the main drive chain. Replace any badly worn or broken links. See Figure 184.

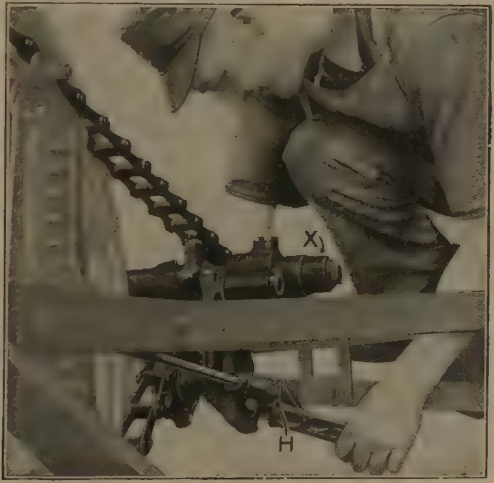


FIG. 184

Spring tightener for the main drive chains. It is easily adjusted and keeps the chain at the proper tension at all times. (Courtesy International Harvester Company.)

2. Inspect the elevator chain for worn or broken links.

3. Inspect the gear on the secondary shaft, which is situated just back of the master wheel, as to mesh. On most machines

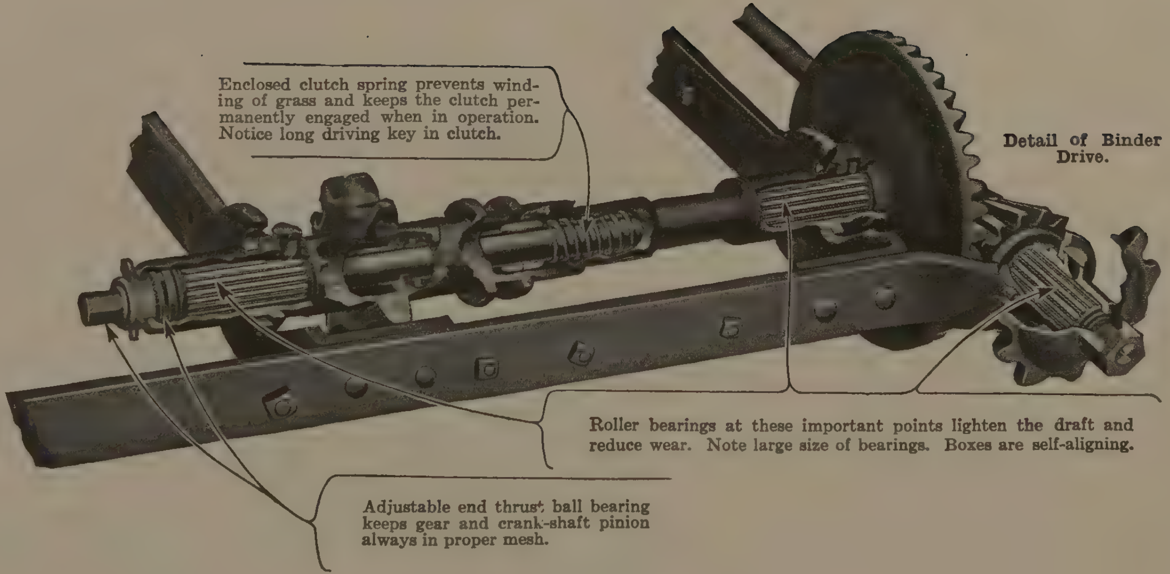

Detail of Binder Drive.
Enclosed clutch spring prevents winding of grass and keeps the clutch permanently engaged when in operation. Notice long driving key in clutch.
Roller bearings at these important points lighten the draft and reduce wear. Note large size of bearings. Boxes are self-aligning.
Adjustable end thrust ball bearing keeps gear and crank-shaft pinion always in proper mesh.

FIG. 185

Detail of binder drive. (Courtesy John Deere and Company.)

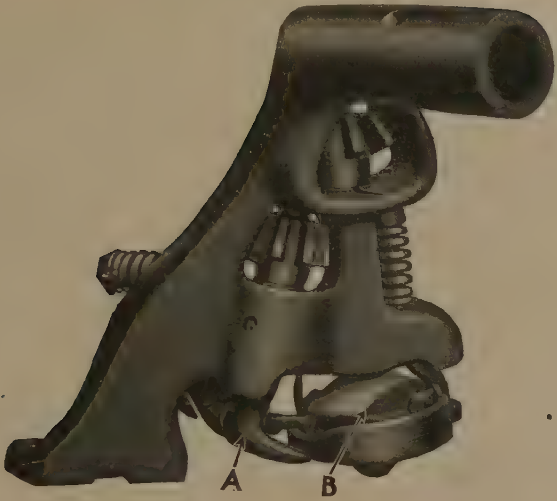
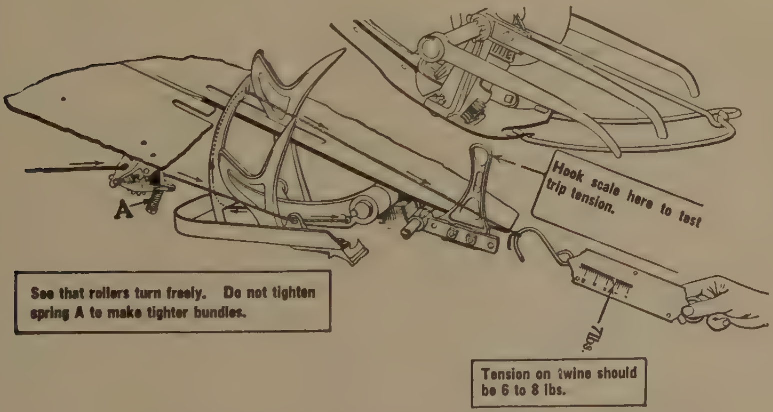


FIG. 186

The knotter has only two moving parts, the bill hook A and the twine holder B. (Courtesy International Harvester Company.)



See that rollers turn freely. Do not tighten spring A to make tighter bundles.

Tension on twine should be 6 to 8 lbs.

In making the test binder must be "home" and properly threaded.
See that tension rollers, hinged tension frame and spring are working freely.

FIG. 187

Testing the twine tension. (Courtesy John Deere and Company.)

an adjustment of this gear is provided for on the end of the secondary shaft opposite the gear, as in Figure 185.

4. The cutting mechanism is essentially the same as that of the mower. No adjustment for alignment is provided for and none for bringing the sections to register.

5. Inspect the canvases for holes, broken or lost slats, buckles, and straps. The holes may be patched by sewing on a piece of heavy denim or overall cloth. Broken slats should be carefully removed and replaced with new ones. Replacement of buckles and straps can be reduced to a minimum by loosening the canvases whenever the binder is not in operation. In case a large amount of millet or flax is to be cut, a strip of canvas tacked on the lower side of the apron has been found to work very successfully.

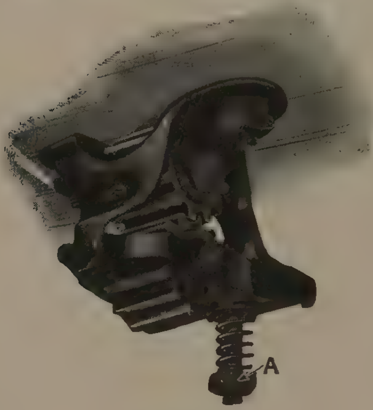


FIG. 188

Twine tension. Adjusted by use of the nut A. (Courtesy International Harvester Company.)

6. All chains and aprons should be run just tight enough to do their work properly.

7. Clean the dirt out of all oil holes and cups with a wire slightly flattened at one end, and give each bearing a liberal application of kerosene.

8. *Binder-head adjustments.* See Figure 186.

a. Test the twine tension with a spring scale as in Figure 187. The tension should be six to eight pounds. Adjust the tension. See Figure 188.

b. Test the tension of the twine holder or disc, as in Figure 189. The tension should be between thirty-five and forty-five pounds. Adjust the twine-disc spring until this tension is secured.

c. The trip tension should be about twenty pounds. Adjust the trip-stop spring until this is secured. See Figure 187.

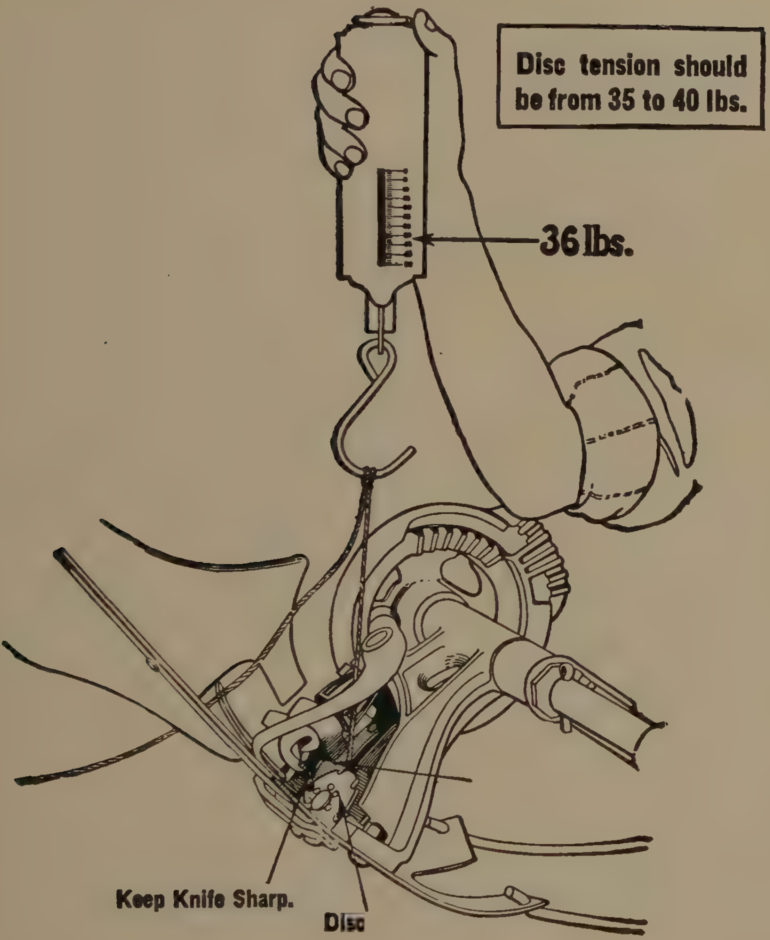


FIG. 189
Testing the tension of the twine holder. (Courtesy John Deere and Company.)

d. In Figure 190 is shown the proper method of sharpening the knife.

e. To adjust the needle, shorten or lengthen the needle pitman B in Figure 191. The needle should come forward far enough to place the twine securely in the twine-disc notches and to permit the knotter hook to catch the upper wine.

f. To regulate the size of the bundle the trip is adjusted on the trip arm. See Figure 187.

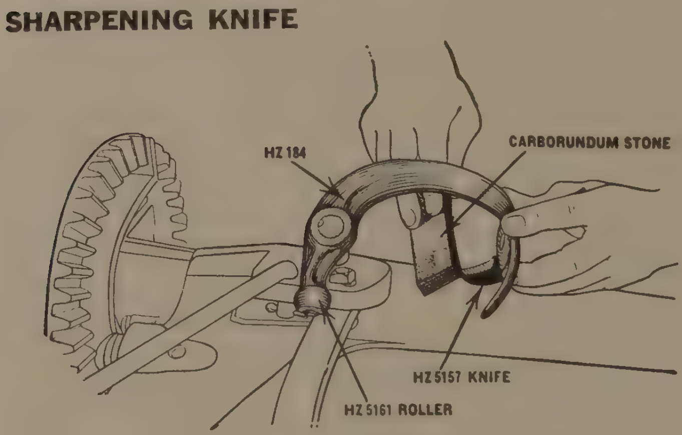

SHARPENING KNIFE

FIG. 190

Sharpening the knife. (Courtesy John Deere and Company.)

9. *Causes of tying troubles* are as follows:
   - a. Broken twine:
     - (1) Twine tangled in twine box.
     - (2) Tension too tight, or parts binding.
     - (3) Poor-quality twine.
   - b. Knot in one end of twine and the other end cut square:
     - (1) Twine-disc spring too loose.
   - c. Knot in one end and other flattened or both ends torn:
     - (1) Twine disc spring too tight.
   - d. No knot in either end of twine:
     - (1) Knotter-hook cam spring too loose.

e. Band broken and hanging in knotter hook:

(1) Knotter-hook cam spring too tight.

f. One end of band slips out as the bundle is picked up:

(1) On an old machine, the disc is too slow due to wear. Insert washers above the worm to advance the disc the proper amount.

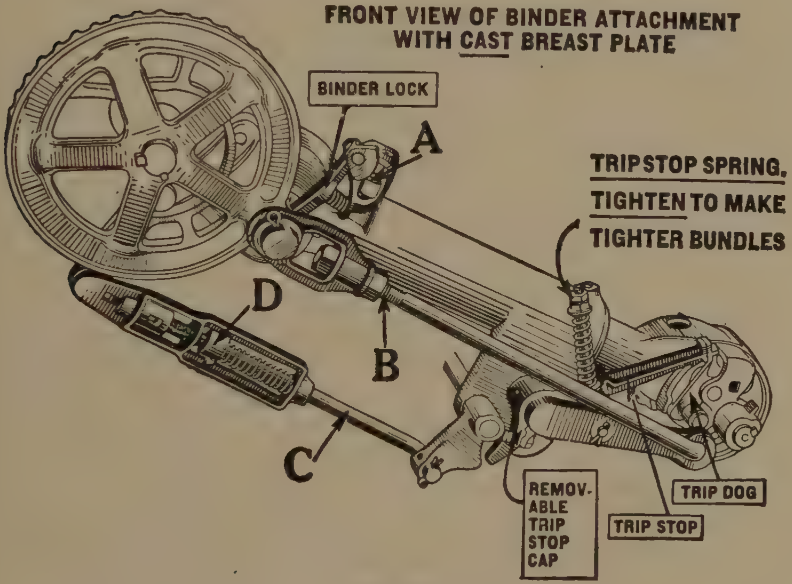

FRONT VIEW OF BINDER ATTACHMENT WITH CAST BREAST PLATE
BINDER LOCK
A
TRIPSTOP SPRING, TIGHTEN TO MAKE TIGHTER BUNDLES
D
B
C
REMOV-ABLE TRIP STOP CAP
TRIP DOG
TRIP STOP

FIG. 191

Adjustment of the needle. (Courtesy John Deere and Company.)

(2) On a new machine, tighten the cord-holder spring slightly.

g. Loop is about the bundle and the twine extends back to the needle eye:

(1) The needle does not go far enough forward to place the twine in the disc properly, due to wearing or improper adjustment of the needle eye.

GUIDE TO SELECTION OF A BINDER

1. Kind of binder (horse-drawn or tractor)?
2. Is machine made by a reputable company?
3. Width of cut?
4. Are the adjustment levers conveniently arranged?
5. Does the binder have transport trucks?
6. Is the reel substantially supported?
7. What type of bearing have the grain and main drive wheels?
8. Has the main drive chain an effective tightener?
9. Is there a convenient means of raising or lowering the binder?
10. What type of bearings has the counter-shaft?
11. How is adjustment made to take up the wear of the bevel gears?
12. Can the canvases be loosened quickly without being unbuckled? See Figure 182.
13. Is the upper elevator-canvas guide flexible at the lower end so as to care for a varying thickness in the feed of grain?
14. How many packers are there?
15. How many discharge arms are there?
16. What kind of butter has the machine?
17. Can the binder head be adjusted easily?
18. What type of bundle carrier (swinging or tip-down)?

PLOWS

The most important part of a plow is the *plow bottom.* The other parts of the implement are merely for the purpose of enabling the operator to make the plow bottom function properly. The plow bottom has the action of a three-sided wedge consisting of the land-side, the share or cutting edge, and the curved mold-board or upper portion of the share.

The *share, land-side,* and *mold-board* are constructed of either soft-center steel, crucible steel, or chilled iron. The soft-center steel is made by welding a bar of low-carbon or soft steel between two bars of high-carbon steel and then rolling the welded material into plates of the desired thickness for making the plow bottom. Soft-center or crucible steel bottoms are lighter than chilled-iron bottoms; they are tougher, but will not wear as long and will rust readily when left exposed to the weather. Chilled bottoms are made by pouring the molten metal into molds which are so constructed as to chill or cool the metal very quickly, thereby rendering it extremely hard. A chilled-iron bottom is heavy, cumbersome, and brittle, but it will outwear a soft-center bottom, especially in gravel soils, and is not affected seriously by rust when left exposed to the weather.

Three general types of mold-board plows are in common use. The *general-purpose mold-board* is designed to plow both stubble land and tame grass sod. See Figure 192. It will scour in a great variety of soils. It is in general use in the older, diversified farming sections. The furrow turned is shown in Figure 193.

The *stubble mold-board* is shorter, steeper, and more abrupt. See Figure 194. It is used in stubble ground and in those soils which are rather loose and tend to stick to the mold-board. See Figure 195. It is not satisfactory for plowing sod land.

The *breaker mold-board* (Figure 196), has a very gentle slope with considerable twist to avoid buckling the furrow slice and to prevent the furrow slice from falling back into the furrow. See

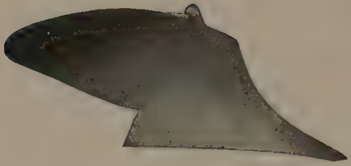


FIG. 192

General-purpose mold-board. (Courtesy J. I. Case Company.)

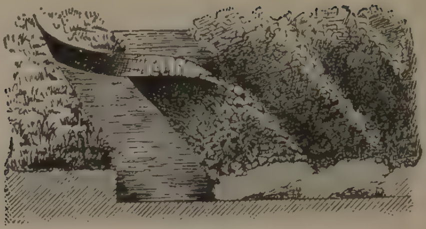


FIG. 193

Furrow turned by a general-purpose bottom. (Courtesy International Harvester Company.)

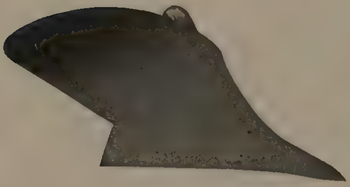


FIG. 194

Stubble mold-board. (Courtesy J. I. Case Company.)

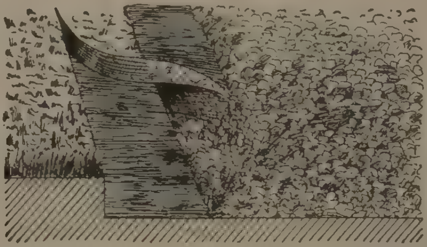


FIG. 195

Furrow turned with a stubble mold-board. (Courtesy International Harvester Company.)

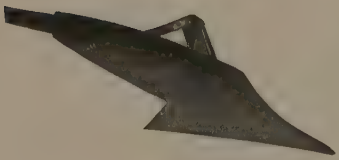


FIG. 196

The breaker-bottom mold-board. (Courtesy J. I. Case Company.)

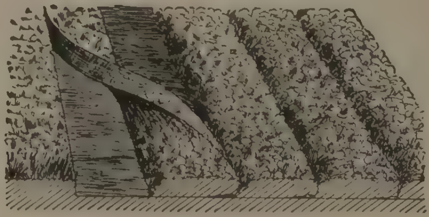


FIG. 197

Furrow turned with a breaker mold-board. (Courtesy International Harvester Company,)

Figure 197. There are a great many variations in the design of mold-boards, each fitted to operate in some particular type of soil.

As before stated, the share may be made of soft-center steel, crucible steel, or chilled iron. For the method of sharpening the soft-center or crucible-steel share, see Job 75.

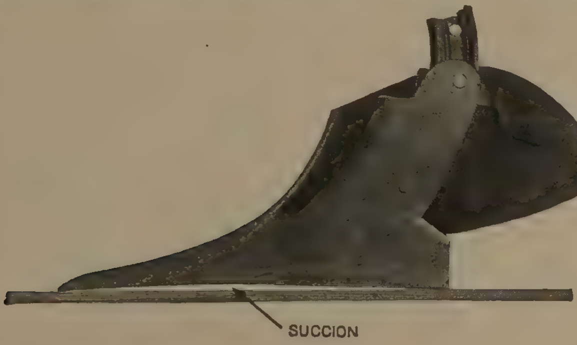


FIG. 198

Correct vertical suction of a plow bottom and share. From 1/8" to 1/4" suction is required. (Courtesy J. I. Case Company.)

Chilled-iron shares cannot be forged out sharp as is the case with the above-mentioned steel shares, but must be ground on the upper side until a beveled edge appears.

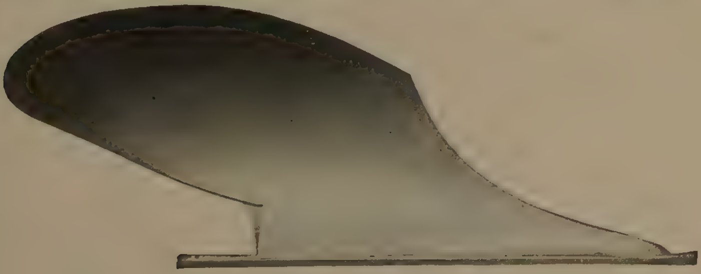


FIG. 199

Wing bearing on the share. (Courtesy Oliver Chilled Plow Works.)

The slight down turning of the point of the share is what is known as "deep suck." This *suction* is necessary to resist the upward pull of the draft. In Figure 198 is shown the proper amount of suction for a plow operating under average conditions. This suction should be between one-eighth and one-fourth inch.

The wing of the share should be so shaped that it rests on a straight edge with the point as in Figure 199.

You will note that the throat is slightly raised on the straight edge.

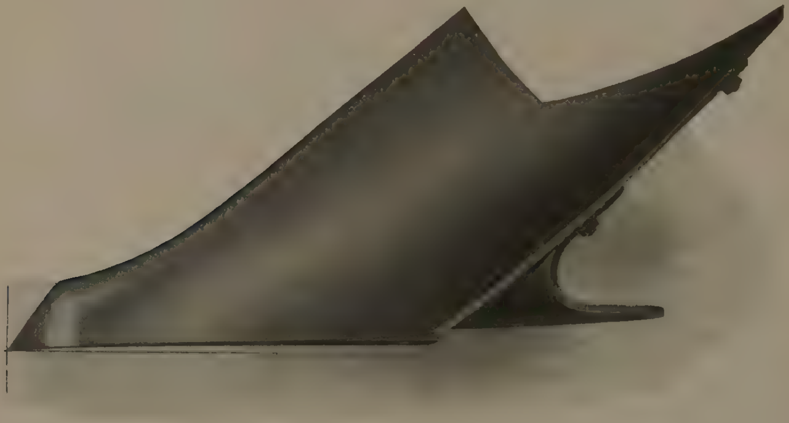


FIG. 200

Land suction of a plow. (Courtesy Oliver Chilled Plow Works.)

Figure 200 shows the proper amount of "land suck." The point of the share should terminate at a point in line parallel with the land-side.

In a walking plow, the land-side takes care of the side pressure exerted on the mold-board by the furrow slice. In the case of the wheeled plow this is carried by the wheels. The land-side of a wheeled plow should not come in contact with the furrow wall nor should it ride on the bottom of the furrow. Some wheeled plows have no land-side.

The *frog of the plow* is really the foundation. To it are attached the share, land-side, mold-board, and often the beam. In the old types of plows using the wooden beam, the frog was made of cast-iron and was very heavy. In some plows the frog is made of malleable iron, but in practically all of our modern plows it is made of either forged or cast steel.

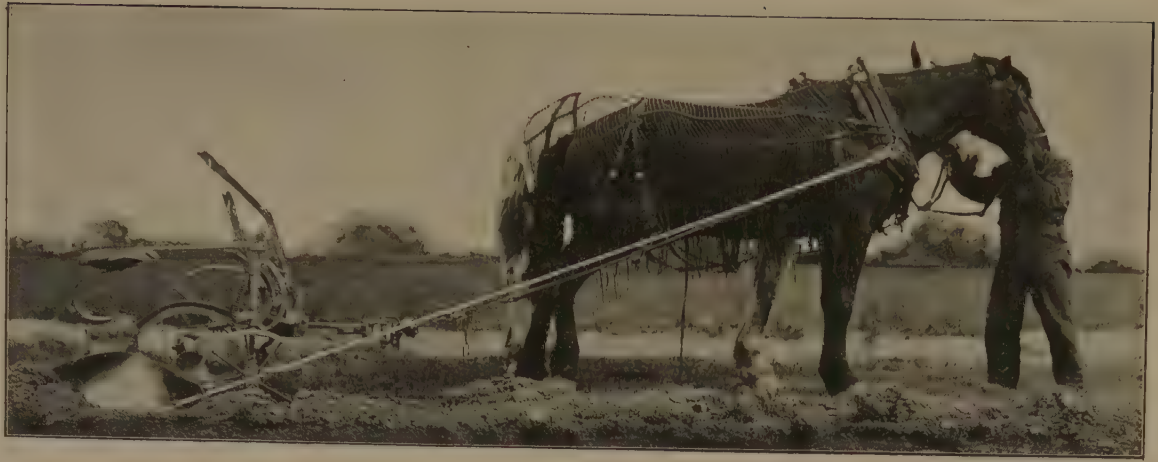


FIG. 201

The correct hitch for a plow. The tugs are parallel to the line of draft from the center of resistance of the plow through the clevis pin to the point on the hames where the tugs fasten the hitch. (Courtesy Oliver Chilled Plow Works.)

An exceedingly important factor in the successful operation of a plow is the *line of draft.* The line of draft should be between the center point of resistance of the plow and the center of power. The center point of resistance of the plow may be taken as a point approximately three inches toward the mold-board side from the furrow wall and two inches above the junction of the shares and the mold-board. In the case of the horse, the center of power is the point at which the tugs fasten on the hames. On the tractor the center of power is considered to be midway between the drive wheels. When the hitch is arranged as in Figure 201, the tugs are parallel to the line of draft from the center of resistance of the plow through the clevis pin to the point on the hames where the tugs fasten the hitch. This line of draft should be maintained in all types of horse-drawn plows. The same principle applies to all tractor-drawn plows. The plow should be so hitched laterally that it runs true with the general line of draft, the width of the furrow slice not to exceed the recommended cut for that plow. On a new plow or one with a new share, a positive test is to observe that the wing of the share extends one-fourth to one-half inch beyond the edge of the furrow slice.

There are some soils in which only a *disc plow* will operate successfully. The disc plow cuts a concave and coarse furrow bottom which is probably more receptive of moisture than the bottom cut by a mold-board plow. In many cases, this type of furrow bottom will prevent soil from washing away. The disc plow will operate very satisfactorily in old stubble ground, in very hard, sticky, or gumbo soils, and in loose soils which are to be plowed shallowly. It is generally a little lighter in draft than the mold-board plow.

JOB 80

TO MAKE THE NECESSARY ADJUSTMENTS ON THE PLOW

Material and equipment.

Eight-inch monkey-wrench; screw-driver; hammer; oil-cans, one filled with kerosene and one with good-quality machine oil; can of cup grease; pliers; cold-chisel; punch; wagon jack.

Procedure.

1. Remove the paint from the mold-board by means of a paste consisting of ordinary lye and water; this should be applied sparingly with a rag tied to a stick. Allow this paste to remain on the mold-board for five or ten minutes, which is sufficient time to allow the lye to dissolve the paint but not long enough to permit it to destroy the highly polished surface of the mold-board. Rub off the paste and paint with a piece of old burlap.

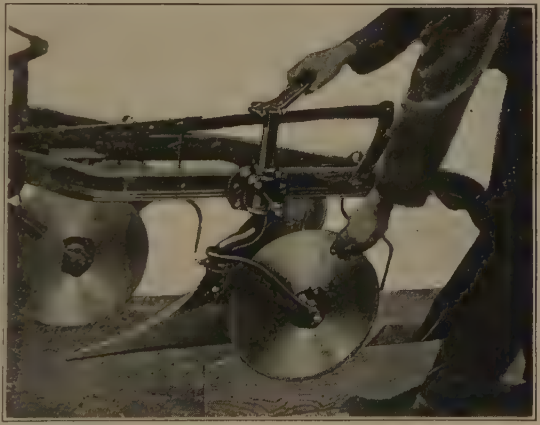


FIG. 202

A thin board placed against the land-side may be used in setting the coulter.

The rolling coulter and jointer should be treated in the same way.

2. All moving parts should be well lubricated with a good grade of machine oil mixed with an equal amount of kerosene.

3. Adjust the coulter as in Figure 202 by placing a one-half inch board along the land-side of the plow. Set the coulter so that it rests flush with the board. The depth of the adjustment is determined by the depth of the furrow slice. In average plowing the coulter should penetrate about three inches. When operating under trashy conditions, the center of the coulter should be placed directly above or slightly ahead of the point of the share. Under all other conditions the coulter should be set just far enough back so it will clear the cutting edge of the mold-board and still penetrate to the desired depth. The bearings of the coulter act freely and run true.

4. Where field conditions warrant the use of a jointer, a universally correct setting is to place the point of the jointer directly below the center of the coulter. There must be sufficient clearance so that the jointer will not interfere with the coulter's rotation, and enough penetration so that all trash will be turned under the furrow slice.

5. *Wheel and tongue adjustments.*

   a. Adjust the pole so that it rests midway between the furrow and the horse and the land horse when they are in a working position.

   b. The rear wheel should be set in relation to the clevis hitch so as to run lightly in the furrow corner, with a slight tendency to carry the rear of the plow to the right.

   c. There are two types of front furrow wheels, one set at an angle and the other perpendicular. The former is designed to run in the corner of the furrow, while the latter should run a short distance from the furrow wall to avoid gathering trash. Both types, however, must operate in a line parallel to the line of draft.

   d. Additional furrow depth may be obtained by perpendicular adjustments on both the front and rear wheel carriages.

6. Generally speaking, the above adjustments hold true in the operation of a tractor plow. Tractor plows are usually run in gangs of two or more bottoms, making a unit usually larger than the horse plow and not quite so flexible.

The successful operation of this type of plow is attained chiefly in the proper hitch between the tractor and the plow. By referring to the general discussion of plows and plow hitches, no difficulty in making the correct hitches should be experienced.

GUIDE TO SELECTION OF PLOWS

1. Kind of plow (walking, sulky, gang, or tractor)?
2. Is the plow made by a reputable manufacturer?
3. What class of bottom is necessary for the soil?
4. What size and number of plows will be most efficient?
5. a. Is the frame rigid or flexible?
   b. Is it substantial enough?
6. What is the method of lubricating the axles?
7. By what means is the dust kept out of the wheel bearings?
8. Can the front and rear wheels be adjusted independently of each other?
9. Can the "deep suck" be varied?
10. Is the lift substantial and efficient?
11. Are the levers arranged conveniently?
12. Can the hitch be varied to suit the different means of power?

GUIDE TO SELECTION OF CULTIVATORS

1. Kind of cultivator?
2. Has it a balancing frame?
3. Are the axles of the expanding type?
4. Are the wheel boxes enclosed?
5. Are the gangs adjustable in front?
   a. Laterally?
   b. Vertically?
6. How many shovels has each gang?
7. What is the type of shovel?
8. By what means can the pitch of the shovels be varied?
9. Can the shovels be forced into the ground by the levers?
10. Is the pole pivotal?
11. Are the wheels pivotal?
12. Is the height of hitch adjustable?
13. What type of shields is employed?

MANURE SPREADERS

Manure spreaders in general may be divided into two classes, as regards the style of apron employed.

The *endless apron* operates in one direction only. When the slats run the full length of the apron, care should be exercised in freezing weather so that the manure which sometimes falls through does not become frozen to the slats. This might break the apron when the spreader goes into operation. With some styles in which the slats are hinged on one side, this difficulty is overcome.

The *return apron* has slats on a little more than half the length of the spreader floor. After the load is spread, this apron is returned by a gear or chain-and-clutch mechanism.

The rollers on which the apron slides should be oiled occasionally. They should also be inspected for looseness and to see that the apron does not drag on the cross braces, which may result in broken slats and increase draft. The apron should be adjusted tightly enough so that the driving sprocket can function without slipping or binding.

Aprons are moved backward by two types of mechanisms. The *worm drive,* which is a continuous drive, consists of a worm which is driven by a small movable pinion operated by a large disc gear. This disc gear is usually fastened to the axle. The rate of feed is regulated by shifting this small pinion on the large disc gear. The worm gear should be inspected for wear often. In the better types of machines, this worm gear operates in a bath of oil. Foreign materials sometimes get into the gear case and it should then be drained and rinsed out with kerosene. It is not advisable to change the rate of feed when the spreader is in motion on this type of drive because of the danger of stripping the teeth on the small pinion.

The *ratchet drive* consists of a large ratchet-wheel which is driven by two pawls. The pawls are actuated by various devices. The load is moved only a short distance by this method, and care should be taken in cold weather so that the teeth on the ratchet-wheel will not be stripped if the apron is frozen tight.

The *clutch* controlling the return of the apron should be inspected for wear, and adjustments should be made when necessary.

The *beater* may be of various types, and either chain-driven or gear-driven. To function properly, the beater shaft should fit snugly but move freely in the bearings. The oil ways should be kept clean. Any broken teeth should be replaced. A satisfactory repair tooth can be constructed from round bar iron or steel of the proper size and threaded so as to leave space for a nut on each side of the tooth bar. Crooked teeth should be straightened by means of a large monkey-wrench or small gas pipe. A broken sill should be immediately replaced because of the danger of throwing the beater out of line.

The *bearings* of the front wheels should be carefully inspected for wear and the oiling system checked over carefully. A liberal use of oil and grease in the bearings and on all moving parts of the spreader will prolong its life and reduce the draft to a very marked degree.

GUIDE TO SELECTION OF MANURE SPREADERS

1. Kind of spreader?
2. Is the machine made by a reliable manufacturer?
3. Type of apron (endless or return)?
4. By what arrangement is the apron supported as the load is moved backward?
5. By what means is the apron kept tight?
6. If endless, how is the inside kept from becoming fouled?
7. How is the apron driven (worm-gear or ratchet)?
8. Can it be thrown out without interfering with the operation of the beater?
9. Is there a wide range of feed variation?
10. a. What is the width between the front-wheel tracks?
    b. Is it apt to produce a whipping motion to the tongue?
    c. Will the wheels turn under the bed pieces?
11. Can the spreader be used in growing corn without injury to the corn from wheels or horses?
12. Is the frame substantial?
13. What is the direction of rotation of the beater?
    a. Is the beater substantial?
    b. Is it moved backward when thrown in gear?
14. Is provision made for taking up the wear of the gears?

The disc harrow is a machine used both for pulverizing the surface soil and for packing it. There are three distinct types of discs used, namely, the solid round disc; the cutaway, in which portions of the cutting edge are removed; and the spader, which consists of a series of sharp blades.

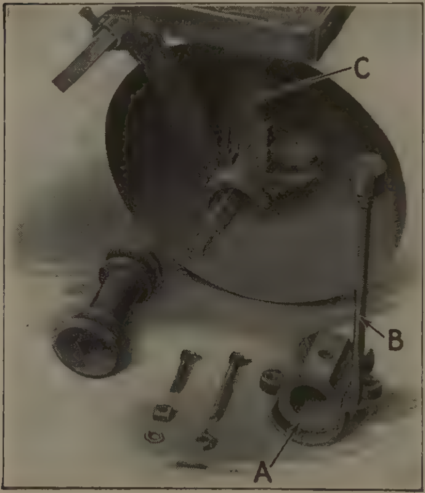


FIG. 203

Disc harrow bearings. Letter A indicates the hardwood bushing that completely encircles the hard iron spool. Grease is forced through the iron standard. The bushing, lettered B, is reversible four times. (Courtesy International Harvester Company.)

The *spader* will work very successfully in wet ground. The *cutaway disc* appears to be doing better work than the *solid disc,* but on close examination one sees that the loose soil is really sprinkled over the unstirred soil which is passed over by the cutaway portion. The spader disc has an action very similar to that of the cutaway disc as far as stirring all of the soil is concerned. The solid disc, on the other hand, stirs all of the soil.

Discs are made in sizes varying from twelve to twenty inches. The smaller the disc, the less the bearing surface, and the deeper the penetration. Due to the tendency of the smaller discs to clog readily, the average size of the discs in common use is sixteen inches. The sixteen-inch disc has sufficient penetration and plenty of clearance for average conditions. Any disc, to have the proper penetration, should be kept sharp. The solid disc may be sharpened with a disc sharpener or on the emery-wheel. In the cutaway disc it is necessary to remove the discs and grind them on the emery-wheel. The spader discs must be removed and each blade heated and drawn out.

The parts of the disc harrow which receive the most wear, with the exception of the cutting edges of the discs, are the bearings. The *most satisfactory bearings* in use are made of hardwood boiled in oil. See Figure 203. These bearings should be carefully inspected for wear and dirt in the oil grooves and in the tubes leading to the bearings. They should be kept properly adjusted and, if worn very much, should be reploced.

Every disc harrow should be equipped with a substantial disc truck so as to relieve the horses of all weight and side lash. The bearings of the truck wheels should be inspected for wear and dirt deposits when the disc is being overhauled.

SMOOTHING HARROW

Of all of the different types of smoothing harrows, perhaps the *lever harrow* has given the most universal satisfaction. It is generally made with a steel frame. It has good penetration, works well in trashy ground, and can be conveniently moved on the road. The range of adjustment of the teeth by means of the levers makes this possible.

It should be inspected for crooked or badly worn parts, loose teeth, bent frame, and loose nuts.

GUIDE TO SELECTION OF HARROWS
(SPIKE AND SPRING-TOOTH)

1. Kind of harrow?
2. Is the machine made by a reputable manufacturer?
3. Is the frame stiff or flexible?
4. By what means can the angle of the teeth be adjusted?
5. Are the teeth fastened to the frame substantially?
6. What is the size and shape of each tooth?
7. Has each tooth a head?
8. Can the harrow be thrown off the teeth for transporting?

DISC HARROWS

1. Kind of harrow (solid-disc, cutaway-disc or spader-disc)?
2. Is the machine made by a reliable manufacturer?
3. Single-disc or double-disc?
4. Is the frame rigid or flexible?
5. a. How many discs are there?
   b. Size?
   c. Clearance between standard and discs?
   d. Shape?
6. a. What kind of bearings (wood or metal)?
   b. Is provision made for keeping out the dirt?
   c. Are there satisfactory means of lubrication?
7. a. Can the scrapers be adjusted easily?
   b. Will they cause the harrow to plug up?
8. How is the end thrust of the gangs taken care of?
9. Are weight pans provided?
10. Are transport trucks provided?

References.

Redebaugh, G. H., *Standard Mechanical Practice in Repairing Farm Machinery and Equipment*, Bruce Publishing Co., Milwaukee, Wisconsin, 1923.

CHAPTER XVI

THE FARM RADIO SET

What most radio listeners want is a simple explanation of "what it is all about" and clear directions as to what to do with their receiving or listening sets and how to do it. Listeners who want more than this can readily get it by special reading on the subject in radio magazines, books, newspaper articles, and special circulars and booklets published by the manufacturers of radio sets. Any person desiring to send and receive messages by wireless telegraphy can do the same thing and, if he is a farm boy attending an agricultural school, his instructor at the school can easily aid him in getting this help. No more is attempted here than to give to beginners helpful information of an elementary nature about the use of a radio receiving set.

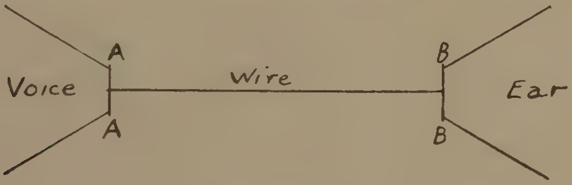


FIG. 204
How the telephone works.

The telephone and the radio work on exactly the same principle. The only difference is that the telephone uses a wire all the way from the speaker to the listener, while the radio uses only the atmosphere (ether).

All of us are familiar with the way in which a telephone is operated, as shown in Figure 204.

The human voice speaks into a mouthpiece. Sound waves from that voice agitate the disc A, which vibrates to correspond with the vibrations of the vocal chords in the throat of the speaker.

By the help of electricity, this disc sets up electrical waves (oscillations) in the telephone wire corresponding to these vibrations. These waves and vibrations are different—strong or weak, long or short—for different sounds.

These electrical waves travel on the wire to a telephone receiving set in another town or a different part of the city. By means of electricity and magnetism again, these waves cause the disc B in the ear-piece to vibrate just as the disc A did.

This sets up again exactly the same sound waves which the human voice sent against A, and these waves reproduce in the listening ear the exact voice and words of the person speaking.

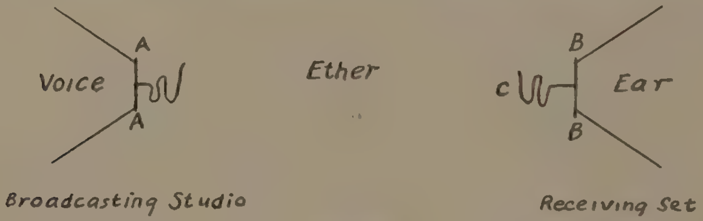


FIG. 205
How the radio works.

The same thing happens if the person telephoning is a singer, or if a pianist or an orchestra plays. Indeed, if you had very strong waves of electricity passing on the wire and used the loud-speaker which the radio employs to make the sounds loud at the receiving telephone, you could entertain your friends with a telephone concert, for example, just as you do with a radio concert.

The greatest difference between a telephone service and a radio arrangement is that you can talk back over the telephone, but you cannot carry on a conversation with your radio set. All you can do is listen to what it says to your ear.

Figure 205 illustrates how the radio works.

The voice speaks or sings, or the instrument is played, at the broadcasting station, or, as the room in which this is done is called, the studio. A disc A is made to vibrate to correspond with the voice, loud or soft, high or low.

They have a way at the broadcasting station of changing these vibrations into powerful electromagnetic and electrostatic impulses or waves which are sent out in every direction through the ether which is in space all around us.

In the receiving set, apparatus is used which changes these ether waves into the form in which they will operate the receiving disc or any other device for reproducing the original sound waves sent in at A. The result is precisely like receiving a telephone message.

At the receiving set at B, many hundred and sometimes thousands of miles away, the wire C (antenna) is strung in the air and connected with the set. This wire, usually called the aërial, catches these electrical waves and sends them into the set.

The disc at B vibrates just as the disc at A does; the same sound waves which agitated A are reproduced by B and the listening ear may hear a speech by the President, grand opera from Chicago or New York, or a vivid description of a football game.

To enable everyone in the room with the receiving set to hear, a loud-speaker is used. This simply reinforces the sound waves so that they can be heard without the use of a telephone head-piece.

We are here concerned only with the receiving set of this radio arrangement. Every beginner wants to know about the following things, which we have taken up in the form of jobs:

1. Selection of a radio receiving set.
2. Purchasing a radio receiving set.
3. How to install a radio receiving set.
4. Testing a radio receiving set to see if it is in working order.
5. Tuning a receiving set.
6. The maintenance of a radio receiving set.
7. Trouble shooting.
8. How to repair the receiving set.
9. How to care for auxiliaries (equipment).

JOB 81

SELECTION OF A RADIO RECEIVING SET

Procedure.

1. Do not try to build your own set. You can buy a better set for less money if you consider wasted and damaged materials and extra troubles with a home-made set.

2. Don't pay an unnecessarily big price for a set. However, obtain the best set that you can afford, right at the beginning. Purchase a set of standard make and of proven value.

3. A set that will work properly may be purchased for from thirty dollars to $600. One can get good service from a thirty-dollar set. There is no doubt that better service and reception from more distant stations result as expenditure is increased to about $100. Beyond that point, one gets more helpful accessories, more conveniences, better workmanship, and a more attractive-looking set, but little better service and reception.

4. The *different types of set* are given below in the order of their cost, starting with the cheapest. Generally speaking, the more vacuum-tubes there are in the set, the more it costs.

   a. The *crystal set* is the most simple of all. As it has an average range of not more than twenty-five to fifty miles, it is usually out of the question for use on the farm. It requires no batteries. The distance or reach of a crystal set may be increased by using an aërial 400 or 500 feet long.

   b. The *single-tube non-regenerative set* consists of one vacuum-tube, a detector, and a tuner with which to find and tune in on different broadcasting stations, which use different wave-lengths in sending through the air. It is more reliable than the crystal set but has little, if any, superiority in range. It requires batteries and is more troublesome to care for than the crystal set without corresponding benefit.

c. The *single-tube regenerative set* is practically the same as the single-tube non-regenerative set just described, except that the regenerative set has an additional coil of wire in the circuit which makes the vacuum tube do double duty as a detector and as a radio-frequency amplifier—that is, the tube acts not only to detect radio waves coming in, but also to reinforce them or make them stronger. As a result, this type of set has been very popular because it has a range of 1,000 miles with head-phones during favorable atmospheric conditions, and because it is inexpensive. It is called a "blooper" because of its tendency to re-broadcast to the air any squealing of the tube. For this reason it is not advisable to buy this type because of the interference it causes for other listeners.

d. The *three-tube regenerative receiver* uses three tubes instead of one to detect and amplify the radio waves. As a result it will, during favorable operating conditions, operate a loud-speaker successfully on broadcasting at a distance of 500 to 1,000 miles. This type of set also causes interference with neighboring sets, and public opinion opposes its use.

e. *Radio-frequency sets* of from five to eight tubes use a vacuum-tube regenerative or non-regenerative detector like type "b" above, but use the other tubes to get two or three different stages of really effective amplification or loudness of sound. As a result, the effective range of these sets is greater than that of the three-tube set. It is easier to select the station wanted and to tune out all other stations. Consequently, those who use these sets are less bothered by interference. "Neutrodyne," "teledyne," and the like are simply trade-names for radio-frequency sets.

f. The *superheterodyne set* is the only one that differs radically from the above sets. No attempt will be made here to explain it. It may be had with six to eight or ten or more tubes. It is easy to operate and does not require an outside aërial.

5. All the above tube sets may be had with either dry-cell tubes or tubes that require a storage-battery. Dry-cell tubes can be operated (that is, the filament in them can be heated) by using

ordinary one and one-half volt number six dry cells, instead of from a storage-battery. Three or six dry cells will be required, depending on the number of tubes in the set, the kind of dry-cell tubes used, and the number of hours per day or week the set is used. Dry cells may be used to fairly good advantage on sets of three or less tubes. With four-tube or five-tube sets, the most satisfactory results will be secured by the use of a storage-battery.

JOB 82

PURCHASING RECEIVING-SET EQUIPMENT

Note.—It is not possible to discuss every type of set and equipment. A five-tube storage-battery set, such as can be bought for about thirty dollars, has been used for illustration. This does not include the cost of tubes or the cost of aërials, batteries, and other equipment outside of the set.

Procedure.

1. Sometimes the question is asked, "Would it be best to start with a one-tube or two-tube set and get a better one later?" The answer is, "No. Get a good one to start with."

2. Sometimes the question is asked, "If I buy a set to-day, is it apt to be obsolete within a year?" The answer is, "No. Refinements are constantly being introduced, but radio receiving-set design and construction have become standardized to the extent that no one need hesitate in purchasing a modern receiver for fear that it may become obsolete. The fundamental principles of radio remain the same, and the set that works to-day will probably work five years from now if properly cared for."

3. The complete equipment necessary for the five-tube set is as follows:

Radio set, including the tubes and tuning coils
Storage-battery
22½-volt B battery
45-volt B battery
Aërial, including lightning arrester
Loud-speaker

4. The question is sometimes asked, "Shall I get a good set and a cheap speaker and then get a better one later; or shall I get a good speaker and a cheap set?" Of the two, the first is the better combination. Undoubtedly, however, a good speaker always improves the tone, quality, and range of the set.

5. If you have a farm lighting plant of the storage-battery

type, the storage-battery of this plant may be used. This will save purchasing one. It can be used either by connecting the radio set with the storage-batteries of the plant, or by shifting the storage-battery from the plant to the farm home. Of course, the second method is very awkward and the first is the better one to follow.

There is one danger in using the lighting-plant battery. If the same set of three cells is used continually with the radio outfit, that portion of the lighting-plant battery is liable to run down more quickly than the rest. The only way to avoid this is to change to a new set of three cells and to do this at regular intervals.

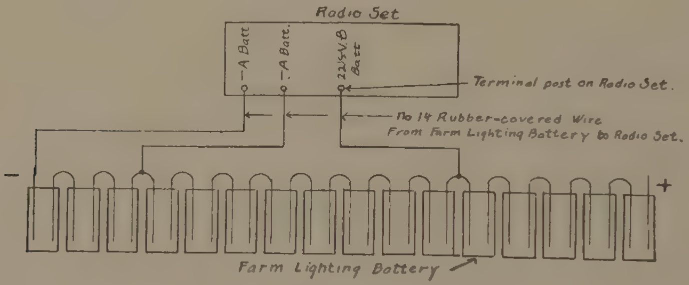

Radio Set
−A Batt
+A Batt.
22½ V. B Batt
Terminal post on Radio Set.
No 14 Rubber-covered Wire From Farm Lighting Battery to Radio Set.
−
+
Farm Lighting Battery

FIG. 206

Simple illustration showing use of farm battery for A and B current of radio set.

7. Figure 206 shows graphically how to connect the storage-battery of a farm lighting plant to a radio set. Care must be taken to connect enough cells to secure the voltage desired.

8. This same lighting-plant battery may also be used as a source of B battery for the detector tube, using six, eight, ten, or twelve of the cells in series, leaving the connection on the one that works the best by trial. The connections for these are also shown in the diagram of Figure 206.

9. Elsewhere in this book, Job 90 tells about how to take care of storage batteries, and the reader is referred to that job in this connection.

If you use a detachable storage-battery for the farm radio set, it will have to be taken to town to be charged. To avoid this, you could alternate it with storage-batteries in your automobile or with storage-batteries in the farm lighting plant, both of which have the advantage of recharging their own batteries.

10. Inasmuch as your lighting system is a D.C. (direct-current) affair, you can, of course, charge your battery directly from the current by inserting a proper resistance coil in series with the line and battery. This resistance coil would have to be at least ten-ohm, and have a carrying capacity of at least ten amperes.

11. The cost of operating a five-tube set such as the one described above is between two and four cents per hour, depending upon the type of set and the cost of charging batteries, cost of B batteries, tube replacement, and repairs on the set.

JOB 83

INSTALLING AND CONNECTING A RECEIVING SET

General information.

Different sets have different ways of marking the leads to which wires from batteries are to be attached. It would of course be impossible here to describe the hook-ups or markings for each type of receiving set in use. It is also true that some receiving sets provide more leads or hook-ups for batteries than others.

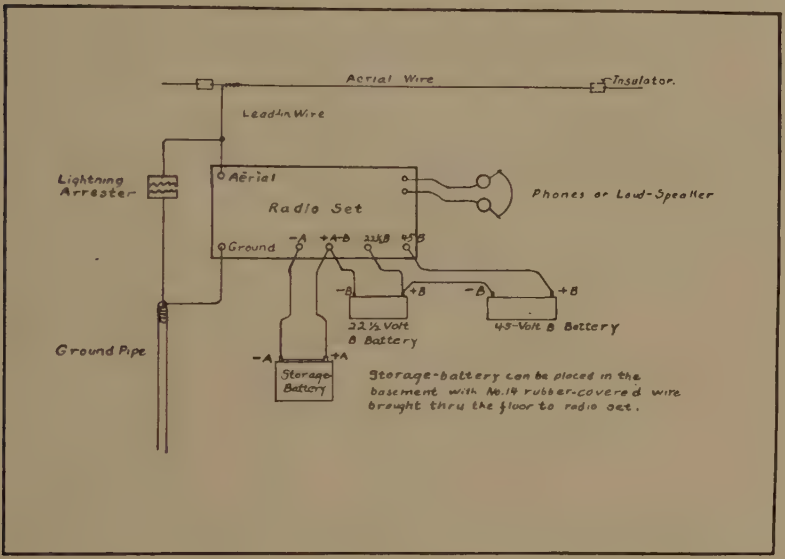
What is done here is to give one of the common hook-ups or connections for a five-tube set. At the same time the reader is urged to follow the directions given for his receiving set in the book of instructions furnished with the set or given by the dealer at the time of purpose.

Procedure.

1. See that the aërial is installed as shown in Figure 208.
2. Place the receiving set on a table or other support as near as possible to the point where the wire leading from the aërial enters the room.
3. Take out all tubes from the receiving set while connecting it with aërial and batteries and keep them out until all connections are made and checked.
4. Figure 207 shows all connections to be made to the receiving set.
5. First connect the ground wire to the binding post on the set marked "ground."
6. Next connect the aërial wire to the binding post on the set marked "aërial." See Job 185.
7. Connect the binding post marked (—A) on the storage-battery to the binding post on the set marked "—A."

8. Next connect the binding post marked (+A) of the storage-battery to the "+A" binding post on the set.

9. Connect the binding post on the twenty-two and one-half volt B battery marked "—B" to the binding post on the set marked



Storage-battery can be placed in the basement with No. 14 rubber-covered wire brought thru the floor to radio set.

FIG. 207

Typical connections of a radio set: phones, batteries, aërial, lightning arrester, and ground connections.

"+A or —B." Sometimes a set has only "+A"; if so, connect to this. Sometimes it has two binding posts, "+A" and "—B." Connect to "—B" in this case. The truth is that whether one binding post or two is found, they are really connected by a wire or other connections inside the set, so that they are really one binding post.

10. Next connect the binding post on the twenty-two and one-half volt B battery marked "+B" to the binding post on the set marked "22½ B."

11. Connect the "+B" binding post on the twenty-two and

one-half volt battery to the "—B" binding post on the forty-five volt battery.

12. Connect the binding post of the forty-five volt battery marked "+B" to the binding post marked "45 B" on the receiving set.

13. Next connect wires from the head-phones or loud-speaker to the proper binding posts on the receiving set. Sometimes these posts on the set are marked "phones," "output," or "loud-speaker." If not marked, they will be the binding posts or plug slots to which no previous connections have been made.

14. Usually the storage-battery is placed in the basement beneath the receiving set and connected by wires from that position to the set.

JOB 84

SETTING UP THE ANTENNA OR AËRIALS

General information.

A good receiving set may be spoiled if the aërial is not what it should be or is not properly installed; hence its importance.

Procedure.

1. Provide a suitable permanent anchor on the wall of the house, preferably just above the point where you expect to place

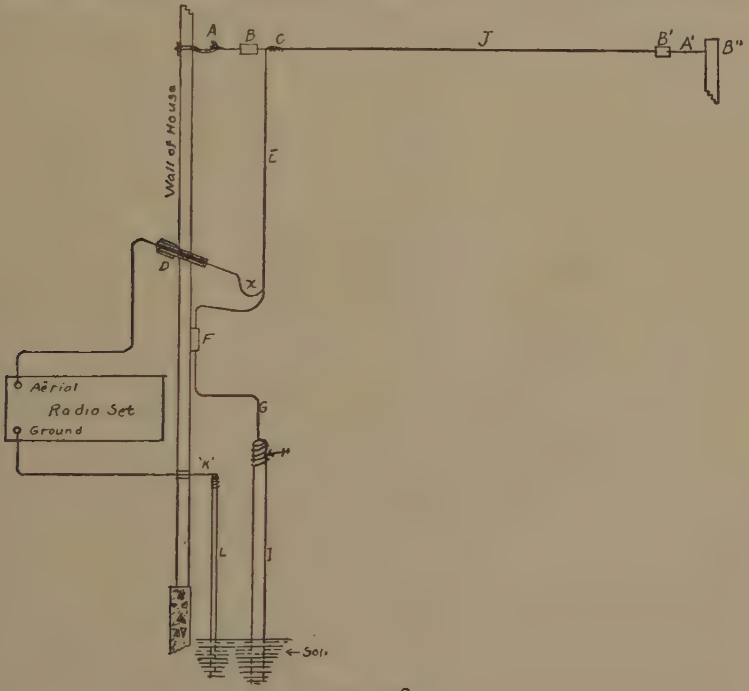


FIG. 208

Diagram showing installation of aërial and ground connections.

your receiving set inside the house. This anchor is usually a five-sixteenths inch "cold-rolled" rod, threaded at one end and terminating in a ring at the other. It should be at least seven and one-half inches long. It is inserted through a hole bored in the wall and bolted with a nut on the inside, usually in the garret. Such a rod may be purchased or forged in the shop.

2. Next take a strain insulator, which comes in the aërial kit and consists of a piece of porcelain with a hole through each end, the holes being at right angles to each other. Fasten a piece of wire about eighteen inches long at one end of this insulator. Fasten the other end of this wire to the hook in the rod which has been bolted to the house wall.

3. Run the aërial wire through the other hole in the insulator and fasten it by twisting the wire.

4. Stretch the wire from sixty to eighty feet toward the point where its free end is to be mounted or fastened. This point will be the top of a barn, windmill, or other outbuilding, or a mast which can be set up.

5. The total length of the whole aërial from the receiving set to the far end of the wire need not be over seventy-five feet. A longer aërial may bring in more volume, but it is less selective.

6. After determining the proper length, fasten the free end of the wire to the second strain insulator.

7. Fasten another wire in some way as high as possible on the barn, windmill, or mast that you are to use. Put the free end of this wire through the other hole of the insulator, and, by pulling on it, draw up the whole aërial until it is stretched fairly tight across the space.

8. Next fasten the free end of the wire by which you have pulled up the insulator by twisting it around itself until it is tight and secure.

9. The whole process described above is shown in Figure 208. In it, A is the rod which is fastened on the house and to the ring of which the aërial is attached. B and B′ are the insulators. J is the main aërial. A′ is the wire from the insulator. B″ is the barn, windmill, or other support.

10. Sometimes this aërial is simply stretched along and above

the ridge-pole of the house. The trouble with this is that with this arrangement it is difficult to get an aërial long enough. An aërial should be not less than sixty feet in length; eighty to 100 feet is preferable. Such an aërial should also be raised at least four feet above the roof, and it is often a difficult and dangerous job to install the uprights on the roof and stretch the wire.

11. There are, of course, many other different kinds of aërials and ways of connecting them, such as cage aërials, loop aërials, and such unusual aërials as coiled springs, balls, racks, pieces of chicken fencing, the house stove, and the like, but they are not considered here. Only one simple, cheap, and safe arrangement is given. Those interested in other kinds of aërials can readily obtain full information regarding them from radio dealers.

JOB 85

CONNECTING THE AERIAL WITH THE RECEIVING SET AND THE GROUND

Procedure.

1. In the aërial kit you will find either a porcelain bushing or a copper lead-in strip. If the porcelain bushing is to be used, it may be installed as follows. From outside the house bore a hole upward through the wall into the room containing the receiving set. This hole is bored upward so that rain can not get through into the room. Insert the porcelain bushing through the wall from the inside so that the head of the bushing is inside as shown at point D in Figure 208.

If the kit contains a lead-in strip instead of a porcelain bushing, put the strip under the sash of a convenient window near the set and on the window-sill. Drop the sash down on this copper strip and connect the lead from the aërial to the outside end of the strip by means of the fastening found on the strip. Do the same with the lead from the receiving set on the inside.

2. Attach a lead-in wire E to the aërial at C. This wire should be rubber covered and of the same size as the aërial. Point C must be soldered. Pass the free end through the bushing at D, leaving a drip loop at X so that water will drip off the wire. You can continue the aërial wire down to the lead-in strip if a strip is used instead of a porcelain bushing.

3. Carry the wire E on through to the receiving set and connect it with the set as shown in the diagram. See also Job 83 on "Installing and Connecting a Receiving Set."

4. Fasten a lightning arrester to the building at F, using wood-screws. Kits usually contain this arrester; otherwise buy one at any radio supply store.

5. At X splice and solder a wire on to E and, carrying it to

the lightning arrester, fasten it to the binding post marked on the arrester as "aërial."

6. Fasten another wire to the lightning arrester and to the terminal or binding post marked "ground." This is wire G in the diagram. It should not be smaller than No. 14, Brown and Sharp Wire Gage.

7. Fasten the free end of the wire G at H at the top of the ground pipe I. H simply shows the wrapping of G around the pipe, but this wrapping must also be soldered. The ground pipe is a piece of one-inch or three-quarters inch water pipe ten to fifteen feet long. It should be driven down to completely moist earth if possible, and should be two or three feet below the frost line of the locality in which you live.

8. The ideal thing to do next would be to install another pipe L just like the pipe I and connect it in the same manner with the free end of a wire from the receiving set as shown in the diagram. In practice, many persons avoid this by connecting the ground wire from the set to H instead of K. If two ground pipes are driven, they should be spaced at least four feet apart.

9. If the house has a water system, the ground wire may be attached to one of the water pipes, provided the pipes are grounded. Excellent results may be secured by attaching the ground wire to the cistern-pump pipe, or better still to the pipe of the well pump.

RECOMMENDATIONS OF THE NATIONAL BOARD OF FIRE UNDERWRITERS FOR PROTECTING YOUR RADIO RECEIVING STATION

To avoid any danger from fire or lightning in a farm-home receiving station, these recommendations, which the National Board of Fire Underwriters has made for receiving stations should be followed:

1. Antenna and counterpoise from all buildings shall be kept well away from all electric-light or power wires of any circuit of more than 600 watts, and from railway, trolley, or feeder wires, so as to avoid the possibility of contact between the antenna or counterpoise and such wires under accidental conditions.

2. Antenna and counterpoise, where placed in proximity to electric-light or power wires of less than 600 volts, or signal wires, shall be constructed and installed in a strong and durable manner, and shall be so located and provided with suitable clearances as to prevent accidental contact with such wires by sagging or swinging.

3. Splices and joints in the antenna span shall be soldered unless made with approved splicing devices.

4. The preceding paragraphs shall not apply to light-and-power circuits used as receiving antennæ, but the devices used to connect the light-and-power wires to radio receiving sets shall be of approved type.

5. Lead-in conductors shall be of copper, approved copper-clad steel, or other metal which will not corrode excessively, and in no case shall they be smaller than No. 14, except that bronze or copper-clad steel not smaller than No. 17 may be used.

6. Lead-in conductors on the outside of buildings shall not come nearer than four inches to electric light-and-power wires unless separated therefrom by a continuous and firmly fixed non-conductor which will maintain permanent separation. The non-conductor shall be in addition to any insulating covering on the wire.

7. Lead-in conductors shall enter the building through a non-combustible, non-absorptive insulating bushing slanting upward toward the inside.

8. Each lead-in conductor shall be provided with an approved protective device (lightning arrester) which will operate at a voltage of 500 volts or less, properly connected and located either inside the building at some point between

the entrance and the set which is convenient to a ground, or outside the building as near as practicable to the point of entrance. The protector shall not be placed in the immediate vicinity of easily ignitible materials, or where exposed to inflammable gases or dust or flyings of combustible materials.

9. If an antenna grounding switch is employed, it shall in its closed position form a shunt around the protective device. Such a switch shall not be used as a substitute for the protective device.

It is recommended that an antenna grounding switch be employed and that, in addition, a switch rated at not less than thirty amperes, 250 volts, be located between the lead-in conductor and the receiver set.

10. If fuses are used, they shall not be placed in the circuit from the antenna through the protective device to ground. Fuses are not required.

11. The protective grounding conductor may be bare and shall be of copper, bronze, or approved copper-clad steel. The grounding conductor shall not be smaller than the lead-in conductor, and in no case shall it be smaller than No. 15 if copper, nor smaller than No. 17 if bronze or copper-clad steel. The grounding conductor shall be run in as straight a line as possible from the protective device to a good, permanent ground. Preference shall be given to water piping. Other permissible grounds are grounded steel frames of buildings or other grounded metalwork in the building, and artificial grounds such as driven pipes, rods, plates, cones, and the like. Gas piping should not be used for a ground.

12. The protective grounding conductor shall be guarded where exposed to mechanical injury. An approved ground clamp shall be used where the grounding conductor is connected to pipes or piping.

13. The grounding conductor may be run either inside or outside the building. The protective grounding conductor and ground, installed as prescribed in the preceding paragraphs 11 and 12, may be used as the operating ground.

> It is recommended that in this case the operating grounding conductor be connected to the ground terminal of the protective device.
>
> If desired, a separate operating grounding connection and ground may be used, the grounding conductor being either bare or provided with an insulating covering.

14. Wires inside buildings shall be securely fastened in a workmanlike manner and shall not come nearer than two inches to any electric light or power wire not in conduit unless separated therefrom by some continuous and firmly fixed non-conductor, such as porcelain tubes or approved flexible tubing, making a permanent separation. This non-conductor shall be in addition to any regular insulating covering on the wire. Storage-battery leads shall consist of conductors having approved rubber insulation.

It is recommended that the circuit from the storage-battery be properly protected by fuses as near as possible to the battery.

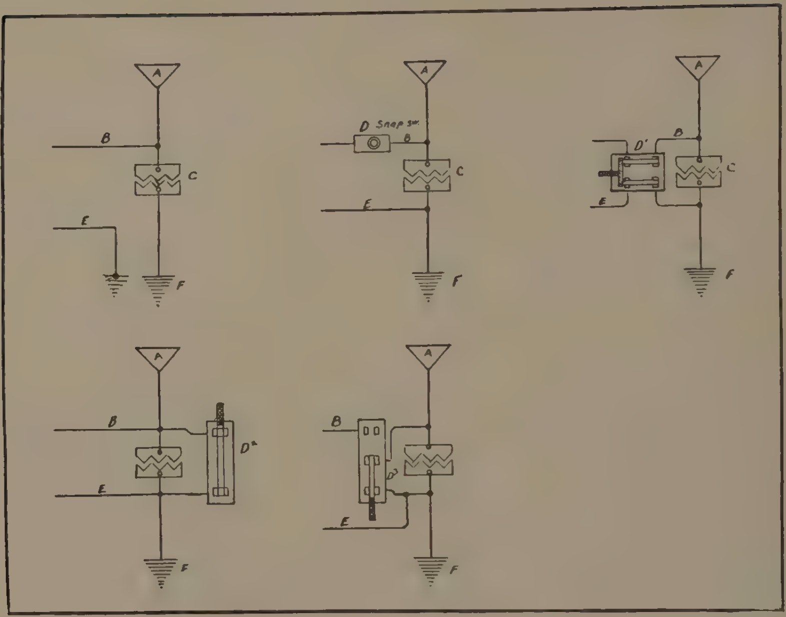


FIG. 209

Diagram showing methods of installing the lightning arrester and ground switch:

(A) Aërial
(B) Lead-in to set
(C) Lightning arrester
(D) Snap switch in lead-in
(D^{1}) Two-pole, single-throw knife-switch in lead-in and set operating ground
(D^{2}) Single-pole, single-throw knife-switch in parallel with lightning arrester
(D^{3}) Single-pole, double-throw knife-switch for grounding the aërial when set is not in use
(E) Ground lead from the set, known as the "set operating ground"
(F) Ground connection

The five illustrations in Figure 209 show various permissible combinations of aërial, lightning arrester, and ground connection, and the use of various kinds of switches in the circuits.

JOB 86

SHOOTING RADIO TROUBLES

Procedure.

1. *Vacuum-tube will not light.* Possible causes: The filament of the tube may be burned out; the A battery may be dead; a loose connection in the set; trouble in the contacts of tubes or sockets in which they fit; battery disconnected; defective rheostat; dirty contacts; wrong connection of A-battery cells.

2. *Tubes light, but there is no sound.* Possible causes: Rundown or dead B battery; A-battery or B-battery connections reversed; wrong connection of B batteries to set; poor contact at plate or grid terminal of tube or socket; broken connection in plate or grid circuits; broken head-phone or loud-speaker lead wires; tubes paralyzed by too much A or B battery; short circuit in phone condenser; broken wire in the amplifying transformers or circuit.

3. *Signals good in detector circuit but poor with the amplifier.* Possible causes: A battery in poor condition; transformer burned out or open; poor connection in sockets; B battery dead; A battery reversed; C battery reversed or disconnected. (In case of any of the following troubles, you should go back to the dealer or other expert to correct the trouble inside the set.) Transformer reversed; condenser short-circuited across transformer; poor amplifier tubes; high-resistance connections in jacks or plugs.

4. *Unusual noises while tuning.* Possible causes: Not enough grid-leak. (The grid-leak is a high-resistance device which permits excessive charges on the grid inside the vacuum tube to leak off or escape.) A-battery current too high; B-battery voltage too high on detector tube; dust between plates of variable condenser; hand of operator touching some metal part of set; poor aërial or ground connections; aërial swinging against grounded object; de-

fective head-phone or loud-speaker connection; too much A battery on tubes; near-by electrical device not operating properly, and so setting up interference. (For the following troubles, go to the dealer.) Poor contact in rheostat; transformers may need a condenser across secondaries.

5. *Howls, squeals, whistles, and the like.* Possible causes: Too much B battery on detector; too much filament current; wrong size of grid-leak; neighboring sets regenerating; improper shielding of panel; improper tuning; poor ground connection; loose ground connection; poor aërial connection; aërial touching other objects. (For the following troubles, go to the dealer for help.). Wrong size of grid-leak; amplifying transformers located too close to each other; improper shielding of panel.

JOB 87

TAKING CARE OF THE STORAGE-BATTERY FOR THE RADIO

Note.—Much of what is said here would apply just as well to the use of the storage-battery in the automobile and in the farm lighting plant, or to any other use for which this invaluable but much-abused servant is applied.

General information.

1. *Battery is weak.* In radio the first indication of trouble is usually the fact that the reception seems to be weak compared with reception when the same adjustments were made previously. One finds he has to keep cutting down the resistance, and turning the rheostat more and more to the right until all of the resistance is cut out. The signals become indistinct and lack sharpness. The set fails to hold up to any one adjustment and requires more and more battery.

2. *Battery is near full discharge.* The set works well when one first starts using it, and then gradually the power fails until it is impossible to make any satisfactory adjustments. The set is dead because the battery has been allowed to discharge itself to the breaking point.

3. *Heed the warnings.* These warnings should be heeded for two reasons: First, the life of the battery demands it. It has given a warning and if its life is to be preserved as long as possible, it must receive the care it demands. Second, with the battery dead, the set is useless.

Procedure.

1. *Chronic battery trouble.* If the set has repeatedly given trouble which can be traced to the battery, look the battery over carefully. The connection or terminals may be badly burned or corroded, making a high-resistance connection at this point, with a corresponding loss of current. The top of the battery may be damp or dirty and thus it may be partially shorted there. The

battery terminals may be badly corroded and result in a poor connection. The wires to the set may be too small and may not have the carrying capacity required. Also, some connections in the set may be corroded or loose. All of these troubles affect the operation of the set and cause running-down of the battery in a much shorter time than usual.

2. *Making voltage and specific-gravity readings.* Voltage readings taken across each cell with a voltmeter and specific-gravity readings taken with a hydrometer are the true indicators of the state of charge of a battery if used together. At full charge a storage-battery should show the following readings in each cell: 2.3 to 2.5 volts and 1.250 to 1.300 specific gravity. At full discharge these readings would be 1.7 volts per cell and 1.150 specific gravity. The readings for different stages between full charge and full discharge will fall between the two sets of figures just given.

Voltage readings alone or specific-gravity readings alone are not true indications of charge or discharge. Something may have happened to throw one or the other out of balance. These readings should always be taken together; also, voltage readings should be taken with some current flowing from the battery. Turn on the set, step on the starter, light the headlights, or blow the horn when taking readings. Of the two readings, the voltage reading will be found to be more dependable, if it is impossible to obtain both at the same time. Specific-gravity readings are often found to be inaccurate. If one of the jars leaks and allows some of the electrolyte to be lost, and this loss is replaced with distilled water, the specific-gravity range has been changed and is therefore no longer a correct indication of charge. Again, if acid is added to replace the natural evaporation of water in a cell, the readings will be thrown off, but in the opposite direction. When a battery shows any of the above indications of trouble, take it to a reliable service-station for correction at once.

3. *Too small a wire often causes trouble.* This is true more often in the case of the automobile than in that of the radio set. The situation is identical with that of the man who tries to fight a serious fire with a garden hose to supply the water. The battery

is perhaps the least-known part of the automobile or radio, and for this reason receives more abuse than any other part. There is no excuse for this, as the battery gives plenty of warning of approaching trouble; and, if these warnings are heeded, it will give long, efficient, and economical service.

4. *To care properly for a battery,* first see that it is brought up to full charge and the acid adjusted to the proper specific gravity by a service-station. As the battery is again put into service, take specific-gravity and voltage readings of each cell and write them down to compare with future readings, which should be taken every two weeks. Keep all readings, and compare them from time to time. When taking these readings, add distilled water to each cell if necessary to keep the solution above the plates. Never use anything but distilled water. Have the battery checked at a service-station once a year at least. Keep the terminals clean, and coat them with vaseline to prevent corrosion.

JOB 88

USING THE INTERNATIONAL MORSE CODE WITH WIRELESS

This book does not deal with wireless telegraphy, which any one might carry on with the proper outfit and the use of the antenna which he had rigged up for his radio receiving set. For his convenience, should he do this, the International Code used in wireless telegraphy is given below. This code is not used in telegraphy by wire.

A .—
B —...
C —.—.
D —..
E .
F ..—.
G ——.
H ....
I ..
J .———
K —.—
L .—..
M ——

N —.
O ———
P .——.
Q ——.—
R .—.
S ...
T —
U ..—
V ...—
W .——
X —..—
Y —.——
Z ——..

Period .. .. ..
Interrogation ..——..
Error ....
Comma .—.—.—
1 .————
2 ..———
3 ...——
4 ....—
5 .....
6 —....
7 ——...
8 ———..
9 ————.
0 —————

CHAPTER XVII

STORAGE-BATTERIES

Storage-batteries have long been looked upon as mysterious contrivances about which little is known. The fact is, they are comparatively simple both in construction and in operation. There is no electricity needed to run a storage-battery; it generates its own energy (electricity).

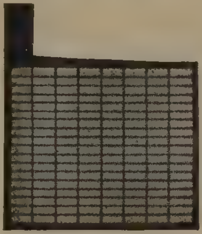


FIG. 210
"Plates" of the battery. (Courtesy National Lead Battery Company.)

A *storage-battery cell* consists of a jar or container made of some acid-resistant and non-conducting substance. Into this cell the elements are assembled. These elements are "plates" (Figure 210), between which wood or perforated rubber sheets called "separators" are inserted. See Figure 211.

These elements are entirely submerged in a solution of sulphuric acid and distilled water, the specific gravity of which generally reads about 1.285 to 1.300 when the battery is fully charged.

FIG. 211
"Separator" of the battery. (Courtesy National Lead Battery Company.)

A cell will always develop approximately 2.5 volts when fully charged. By connecting any given number of cells in series, any desired voltage may be obtained. Capacity is determined by the amount of active material in a cell. The capacity may be increased or diminished by building cells of various sizes. These odd sizes are made by increasing or diminishing the number of plates in a cell.

JOB 89

TESTING GRAVITY

Material and equipment.

Battery; hydrometer.

Procedure.

The amount of charge of a battery can be determined by the use of a hydrometer. The vent plugs are removed and the hydrometer is inserted in the cell. If the bulb is pressed and then allowed to expand, a small amount of the solution will be drawn into the glass tube, causing the unit in the tube to float. The correct reading is given at the surface of the solution in the hydrometer tube. It is very important that the hydrometer be held vertically so that the float does not stick to the glass tube and thus give a false reading. After the reading is obtained, the solution is replaced and the vent plug reinserted. The other cells are inspected in a like manner. The reading may vary fifteen points between cells without affecting its performance.

The hydrometer float will show a reading of approximately 1.285 to 1.300 when the battery is fully charged; a reading of 1.150 to 1.175 shows that the battery is discharged.

Automobile batteries serve the car in three ways: for lighting, ignition, and starting. The most common battery used in automobile service to-day is of the six-volt type, consisting of three cells with a capacity ranging from eighty ampere-hours up to 175 ampere-hours. See Figure 212.

The care of the automobile battery is simple; and if it is properly treated, its life will be greatly prolonged. It should be kept tightly bolted in its compartment, and for this purpose all car manufacturers equip their cars with battery "hold-downs." These hold-downs consist usually of a bolt, a nut, and a clamp. The clamp usually fits over the top of the handle or case, and when the nut is tightened, the battery is held firmly in place. If the hold-downs are not used, the battery bounds around in the carrier as the car travels over the road, resulting in breakage and greatly decreased life.

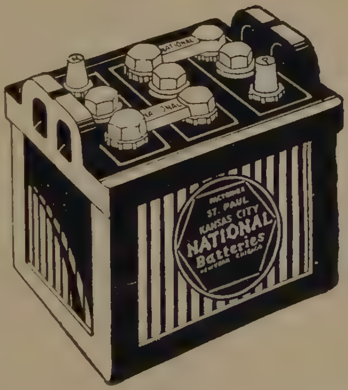


FIG. 212

Automobile Battery. (Courtesy National Lead Battery Company.)

The automobile battery should be inspected every two weeks during the summer months to determine whether or not it is necessary to add distilled water. This can be determined by removing the vent plugs from the cells. If the solution is below the top of the plates, enough distilled water should be added to cover them. The battery cells must not be completely filled to the top.

During the winter months, once in three weeks should be often enough to add distilled water.

Keep the battery clean. It is well to wipe off the top occasionally, using a damp cloth. This eliminates the possibility that dust will collect moisture on the top of the battery, and does away with any chance of self-discharge from that source.

The terminals should be securely fastened to their cables to insure good contact. It is advisable to apply a thin coat of grease or vaseline to the terminal posts of the battery before connecting the cables, in order to prevent the corrosion which generally occurs.

Never allow the battery to stand long in a discharged condition. A discharged battery usually has a gravity reading of about 1.150 to 1.160. If it is allowed to stand in this condition for a time, a coating of a white substance called sulphate forms on the plates, decreasing the efficiency of the battery and eventually rendering it useless.

If the car is put in storage for the winter or is not in use for any reason, the battery should have care. It should be fully charged and set away in a clean, dry place. At intervals of six weeks it should be inspected and tested, and when the gravity of the solution again reaches approximately 1.150, it should be recharged.

RADIO "A" BATTERIES

Radio "A" batteries are no different from starting and lighting batteries used for automobiles. The same general construction is used. Many people, however, feel that a radio battery does not receive the rough wear nor give the service of a starting and lighting battery, and therefore does not require so much care. It must be remembered that the radio "A" battery performs a delicate task; and that, in view of this, it must be kept in good condition. The instructions for caring for the automobile battery should be carried out in looking after the radio battery.

FARM LIGHTING BATTERIES

The farm lighting battery should have very close attention. It should be *located* in a clean, dry place where ventilation is reasonably good. The best service will be rendered by a battery located fairly close to the source of current. The capacity of a battery is greatly affected by temperature. At extremely low or high temperatures, lead batteries are not nearly so efficient as at temperatures between 60° and 80° so that the battery should be located where the temperature is virtually constant and within the above range.

The *gravity range* of a set of farm lighting batteries is somewhat different from that of automobile or radio batteries. The following table showing charging rates and other data will give the gravity readings of charged and discharged farm lighting batteries:

TABLE 2

Plates per cell	*Normal start*	*Charging rate finish*	*Ampere-hour capacity*	*Gravity charged*	*Gravity discharged*
5	10	4	60	1.230	1.170
7	15	5	90	1.230	1.170
9	20	6	120	1.230	1.170
11	25	7	150	1.230	1.170
13	30	8	180	1.250	1.170
15	35	9	210	1.250	1.170

JOB 90

CARING FOR A STORAGE-BATTERY

Material and equipment.

Hydrometer; emery-cloth; pocket-knife; pliers; rag; bottle of ammonia; cup grease or vaseline.

Procedure.

1. Remove the vent plugs and insert hydrometer in cell, drawing solution into tube. The gravity reading is given at the surface of the solution. Replace the solution after the reading is taken. If the gravity reading is in the neighborhood of 1.150, it indicates a discharged battery, which should be recharged by a reputable battery service-station. If the reading is 1.200, use the starter and lights sparingly until the specific gravity is raised to 1.285 or 1.300, which indicates a fully charged battery.

2. Add enough distilled water to each cell to bring the level of the electrolyte approximately one-quarter inch above the tops of the plates. Do not fill the cells full. Replace the vent and plugs.

3. Wipe off all sediment and electrolyte with a cloth miostened with ammonia.

4. Examine the terminals. Make sure that they are absolutely tight. If badly corroded, remove and scrape the posts and terminals clean with a knife and emery-cloth. Replace and tighten.

5. Put a thick coating of cup grease or vaseline over the connections to protect them against further corrosion.

6. Any battery in service should be inspected every two weeks in warm weather and every three weeks during the winter months.

CHAPTER XVIII

LIGHTING

Light is a form of energy which affects the optic nerve. We see objects because light from some source is reflected by these objects and finds its way to our eyes. Contrast plays an important part in what is called vision. For example, a white mark on a blackboard is easily seen, while a white mark on a white background is hardly visible. The nature of the surface is also very important. Ordinary black printing on glazed paper is often very trying to the eyes because of the glare, while the same type on an unglazed surface is easily read. The human eye accommodates itself to almost all conditions, admitting either little or much light as occasion requires. Because of this fact, we frequently abuse our eyes by asking them to do things which they are not capable of doing without severe strain. A great many cases of defective vision are due to improper lighting conditions.

There are many things that make for good illumination, but the most important of all is the light itself. It must be sufficient in quantity and of good quality. The best possible light is sunlight, and the best artificial light is the one which most nearly approaches sunlight in quantity and quality. Sunlight, sometimes called white light, is a combination of all colors. Some objects appear one color and some another because they reflect those particular colors. If the light does not contain these colors, the objects cannot reflect them. This can be easily demonstrated by putting about a cupful of salt on a metal dish, such as a pie tin, and pouring over it a small amount of alcohol. When the alcohol is ignited, any red objects viewed in the resulting light will appear black. This is because the light contains no red rays to be reflected.

Artificial lighting, as we know it today, is of comparatively recent origin. Previous to the discovery of petroleum, all artificial lights were produced by burning either vegetable or animal fat. One exception was lighting by gas, but this was scarcely an exception because it was possible only in certain localities and was little used for many years after its discovery. We of the present day have our choice of a number of different methods of lighting: we may use candles, kerosene lamps, acetylene, "blau-gas," gasoline, gas, or electricity.

Candles are little used at present except for religious purposes, for table decoration, or for emergencies. They are almost invariably made of paraffin with a cotton wick through the center. When this wick is lighted, the heat melts some of the wax, which is drawn up into the wick by capillary attraction and burned. The resulting light is caused by the red-hot particles of carbon in the flame. When the candle has been burning for some time, the wick becomes charred and its capillary powers are destroyed. This charred portion should be removed. Our grandfathers used for this purpose a device called a snuffer, and the process was known as "snuffing the candle."

Kerosene lamps may be divided into two general classes, the open-flame and the mantle lamps. The process in the open-flame lamp does not differ materially from that which takes place in the candle. Kerosene is drawn up into the wick by capillary action and burned in the open air. The amount of light given out is directly proportional to the size of the wick and the amount of kerosene burned. There is undoubtedly some difference in the efficiency of the different types of burners, but not so much as is claimed. Most of the burners now in use will give good results if kept CLEAN. The charred portion of the wick should be *rubbed* off every day, and never *cut* off. The burner should be taken off the lamp occasionally and boiled to clean out the air passages. A good grade of kerosene should be used and the fount kept as nearly full as possible. Needless to say, the chimney should be kept clean.

Acetylene gas, sometimes known as carbide gas, is produced by the action of water on calcium carbide. Calcium carbide is a grayish material looking something like finely crushed rock. It is made by fusing together coke and limestone. Both of these materials are highly refractory, and an intense heat is necessary. The usual process is to melt them in an electric furnace.

In practice, acetylene gas is always produced in some kind of a generator. See Figure 213. This generator may be located in the basement of the building, but more often is in an outside pit. See Figure 214. The gas is piped to the buildings to be lighted and burned in special jets or tips. These tips are made in such a way that two small streams of gas impinge on each other and produce a flat flame of intense brilliance. The tips are made in various sizes and use gas at the rate of one-half, three-fourths, or one foot per hour.

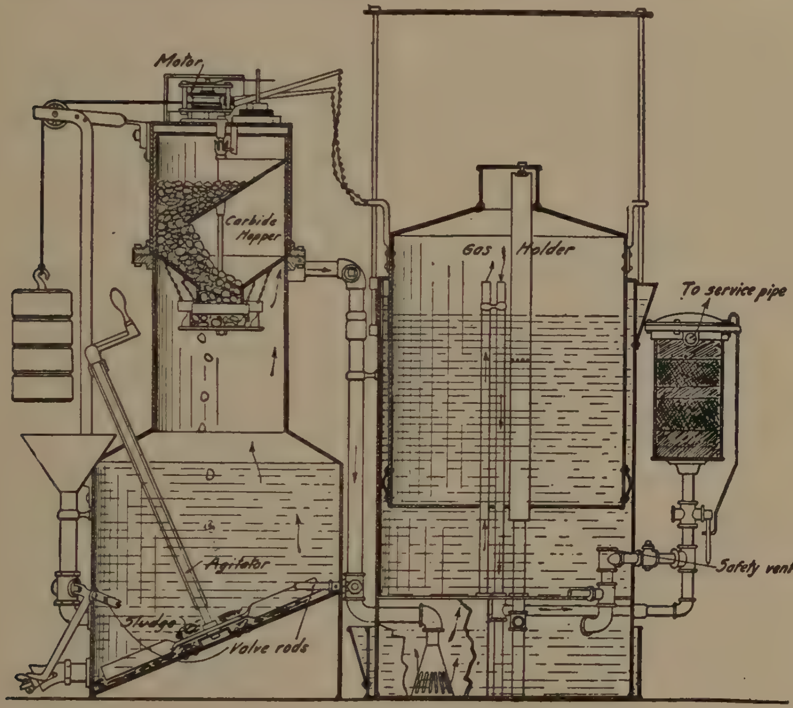


FIG. 213

Acetylene gas generator adaptable for installation in a basement. (Courtesy University of Minnesota.)

Acetylene gas is highly explosive and must be handled with care. This property of being easily ignited is one of the chief advantages of acetylene, since it permits the gas to be ignited by a spark. In nearly all acetylene installations, the burners are equipped with some sort of a friction lighter. The gas is turned on, and when a spark is produced near the burner, the gas at once ignites.

In burning, acetylene consumes very little oxygen and produces a brilliant white light not far from sunlight in quality. The gas has a very disagreeable odor, which in reality is a good thing, since leaks are easily detected. It has no harmful effects on plants, nor does it

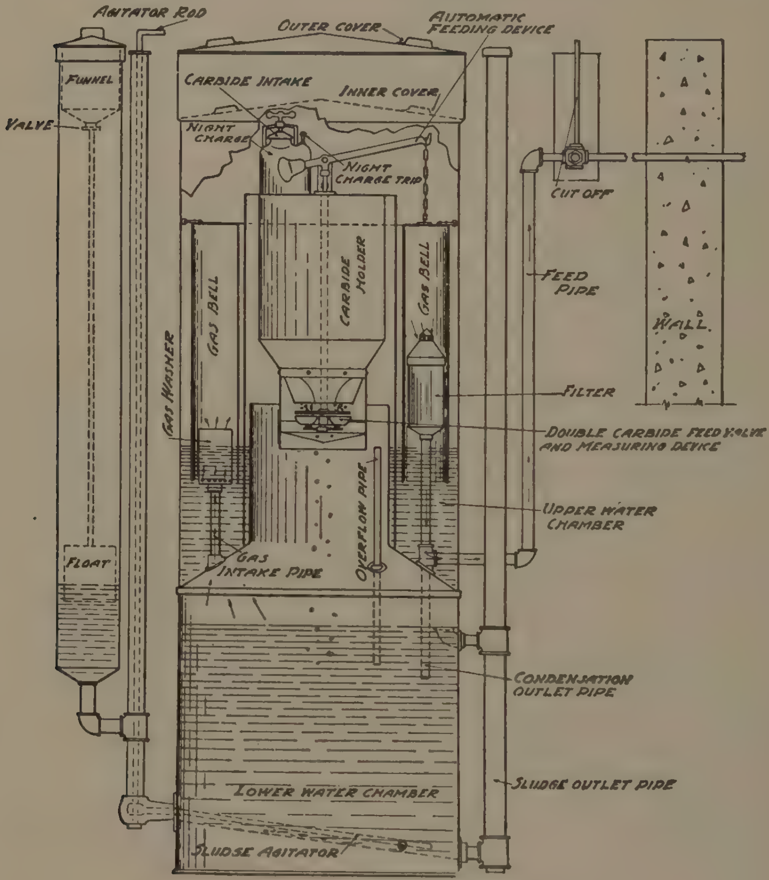


FIG. 214

Acetylene gas generator stored away from the buildings. (Courtesy University of Minnesota.)

tarnish silverware as do the gases containing sulphur. It is not poisonous, since it contains nothing but carbon and hydrogen. A person confined in a room in which there was an open gas-jet would eventually die from suffocation, but would not be poisoned.

Calcium carbide is easily obtained in most localities in 100-pound drums, and costs about six cents a pound. Each pound of carbide will produce from four to six cubic feet of gas, averaging perhaps four and one-half, thus making the cost about one and one-half cents per cubic foot. A one-foot burner will cost about one and one-half cents per hour to operate. The average family will use about 400 pounds of carbide a year for lighting purposes only, making the yearly cost approximately twenty-five dollars.

Acetylene is also used for flat-irons and gas stoves. It is very convenient, but rather expensive to use extensively for cooking purposes. The average stove burner uses four feet an hour at a cost of about six cents.

Carbide is obtainable in several sizes, the usual size for domestic installations being ¼″ x $\frac{1}{12}$″. That is, it will pass a screen having meshes one-quarter inch long by one-twelfth inch wide. A smaller size known as "electrolyte" is used for special devices, such as bicycle lamps. The gas is also sold dissolved in acetone and known under the trade-name of "Prest-O-Lite."

Users and prospective users of acetylene should clearly understand that the gas is highly explosive and that it should be handled with care. The generator should *never* be filled by artificial light nor should leaks be hunted with a match.

"Blau-gas" is made from a petroleum product known as gas oil and gets its name from a German, Herman Blau, who discovered how to put it to practical use. The gas is made in much the same way as ordinary city gas or coal-gas, that is, the oil is injected into heated retorts and there converted into a gas. It is then pumped into a holder after going through several purification processes. In the gaseous state it is much too bulky to be transported, so it is liquefied and sold in steel containers holding twenty or thirty pounds of the liquid gas.

The liquefaction process is very interesting. By means of suitable pumps and compressors, the gas is gradually put under a pressure of about 1,200 pounds to the square inch. The compressor and pipes are kept cool, and finally, after several stages of compression and cooling, most of the gases are changed to a liquid. In the process, some of the gases, notably carbon monoxide (CO), are literally squeezed out. This gas (CO) is the part of coal-gas that causes so many deaths throughout the country. Blaugas as used is not asphyxiating, due to the fact that the poisonous properties have been removed. This gas has a rather sweet, sickish odor, and is not particularly objectionable to most people.

The gas comes to the user in steel bottles which look like the carbon-dioxide bottles used at soda-fountains. These bottles are connected to the house piping through a reducing mechanism and an expansion tank. The liquid gas is first reduced from a pressure of about 1,200 pounds to from forty to sixty pounds in the expansion tank, where it changes from a liquid to a gas, and then is reduced again to a pressure of about six ounces as it enters the house pipes.

"Blau-gas" is used quite extensively for lighting and also for cooking and laboratory purposes in consolidated schools and other institutions where city gas is not available. When used for lighting purposes, it is invariably burned in a mantle and produces a soft, bright light of excellent quality. It may be burned in any ordinary gas stove, and gives an intensely hot blue flame.

The liquid gas is shipped under a low freight rate from the plant to the consumer, who pays the freight on the full bottle. The manufacturer pays the freight on the returned empty bottle. One pound of liquid gas will make about twelve cubic feet of gas as used in the house. The cost will average about one and one-half cents per cubic foot. This cost is not so high as it seems, however, since blau-gas, like acetylene, is extremely rich in heat units. A cubic foot of either gas will produce about 1,800 heat units as compared with about 600 or less for ordinary city gas.

The cost of installing either blau-gas or acetylene outfits depends largely on the size and number of outlets, but seldom exceeds $500.

Gasoline lighting equipment may be divided into two general classes, depending on how the gas is generated. In one type, the gasoline is forced to the burner by gravity or air-pressure and then converted into a gas by heat, while in the other type the gasoline is mixed with air or carbureted, usually outside of the building, and the resulting gas is piped to the burners.

All of the portable gasoline lamps and lanterns as well as the so-called hollow-wire systems are of the air-pressure type. Some sort of a container is partially filled with gasoline, after which air is forced into the space above so as to put the gasoline under pressure. A small tube leading from the bottom of the gasoline chamber conveys the liquid gasoline to the burner. In all such devices, the burner or some part of it must be heated by some outside means before gas is formed. Gasoline vaporizes quite readily under normal atmospheric conditions, but much more readily if heated. Average gasoline will be completely vaporized at a temperature of 450° F. or less. The usual means of producing this heat is to hang a small lighted alcohol torch, or a piece of asbestos soaked in alcohol, under the generator. In one make of lamp, the gasoline is forced through a small copper tube which is formed into a loop. The heat from two parlor-matches is sufficient to generate gas in this lamp.

Gasoline gas, when used for lighting purposes, is practically always burned in a mantle. The gas is mixed with air in the proper proportion to produce an intensely hot but practically non-luminous flame. The intense heat of the burning gas causes the mantle to become white-hot or incandescent. The quality of light is very good and the cost is exceptionally low. The chief disadvantage of these lamps, particularly the portable ones, is the short life of the mantles.

Hollow-wire systems are the same in principles as the portable lamps. The gasoline tank, holding several gallons, is placed outdoors or in some adjacent shed or building, and the gasoline is conveyed to the burners by means of a small, flexible brass or copper pipe ordinarily known as a hollow wire. Any ordinary gas-fixtures may be used.

The carburetor type of plant is more adapted to larger installations. The capacity varies from twenty-five to 1,000 lights. It is also used quite extensively for making gas for use in laboratories. In this machine the gasoline tank and mixing chamber are buried outside of the building, while the moving part or meter is in the basement. Pressure is produced by causing the meter to revolve, thus forcing air through the gasoline. There is never any large amount of gas in storage; it is made as needed. These machines are entirely automatic and require no attention except an occasional filling of the gasoline tank, and raising of the weight, if one is used for motive power.

It is well to remember that any gasoline-burning device works best on a good grade of gasoline. In almost all such apparatus, the gasoline must at one time or another pass through a very small hole, and for best results it should be carefully strained, preferably through chamois skin.

Electricity is probably the best allround lighting medium yet devised. It may or may not have decided advantages over other means of producing artificial light, depending on circumstances. In general, it is more expensive, but has wider applications. In its earlier days electricity was available to only a few people, namely, those who lived in cities and some of the larger towns. American inventive genius, however, has made electricity possible in every home, regardless of location.

The isolated electric-lighting plant has made many farmers potential users of electricity, while a favored few are so located that they may take advantage of cross-country power lines.

Experience seems to indicate that the most satisfactory method for securing electricity for the farm is through power lines built, owned, and maintained by the power companies, which charge the consumers enough to take care of such items as interest and depreciation, and depend on the sale of energy for their profit.

One arrangement is that the consumer shall pay a certain monthly fixed charge, perhaps five dollars or more, and in addition shall pay for all energy used. The energy charge might be as follows: the first thirty kilowatt hours at ten cents, the next thirty at seven and one-half cents, and all additional at five cents. The fixed and energy charges vary so widely, depending on local conditions, that it is impossible to say what the cost will be. The rural consumer may be sure, however, that his energy is going to cost him more than it does the man in town. A little thought will make the reason for this apparent. It costs the power company a certain amount to generate energy, whether for rural or for city customers, but the delivery charge increases very rapidly with the distance from the power-house and the scarcity of consumers.

In common with all other commodities, the unit cost of electrical energy decreases with the amount used. Under present conditions, electricity for lights only must be considered a luxury on the average farm. If the energy can be used for power purposes, the cost per unit is materially reduced. For example, a farmer has his buildings wired and uses current for lights only. His first bill is as follows:

Fixed charge	$ 6.00
30 K.W.H. at 10¢	3.00
	$9.00

Cost per K.W.H., 30¢.

He puts in a motor-operated water pump and his next bill is:

Fixed charge	$ 6.00
30 K.W.H. at 10¢	3.00
30 K.W.H. at 7½¢	2.25
50 K.W.H. at 5¢	2.50
	$13.75

Cost per K.W.H., 12½¢.

He puts in an electric range and an electric incubator, and his next month's bill is:

Fixed charge	$ 6.00
30 K.W.H. at 10¢	3.00
30 K.W.H. at 7½¢	2.25
200 K.W.H. at 5¢	10.00
	$21.25

Cost per K.W.H., 8.17¢.

This man is now getting his energy cheaper than the average city user.

If conditions are such that it is not possible to connect with a high line, electricity may still be had through use of any one of the small isolated plants. The prospective user has the choice of a thirty-two volt or a one-hundred-and-ten volt plant. He may select an automatic or a manually controlled outfit. It may or may not use a storage-battery, and may be air or water cooled. It may vary in capacity from 200 or 300 watts up to 3,000 or more.

The most common capacity is about 1,000 watts. A plant of this capacity delivers current at a pressure of thirty-two volts and uses a storage-battery. See Figure 215. Such a plant will cost, with the house wiring, about $600, and will furnish current at from eight to fifteen cents per kilowatt hour. The average cost will not be far from eleven or twelve cents per kilowatt hour.

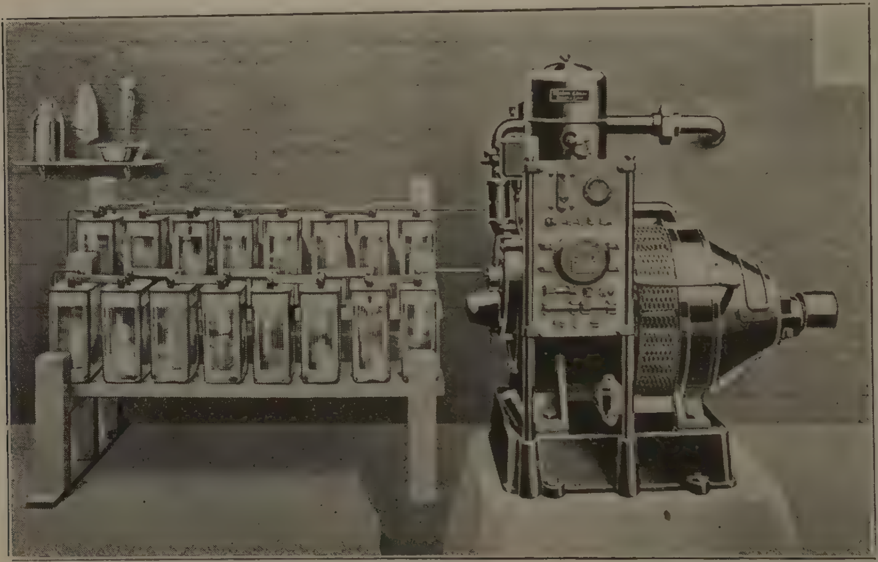


FIG. 215

A type of farm lighting plant. (Courtesy University of Minnesota.)

There are many factors which will influence the purchase of a lighting plant. A few of the more important points are:

Fuel used: kerosene or gasoline or both.
Possibilities of service when things go wrong.
Reliability of dealer and manufacturer.
Financial standing of manufacturer and probability of his continuing in business.
Distance the current is to be conveyed and amount of power to be used.

The average small isolated lighting plant has a very limited amount of power available for other purposes than lights. In most cases it is inadvisable to use a motor of more than one-half horse-power, and this should be used only when the generator is running. The chief difficulty experienced with small lighting plants is the rapid deterioration of the storage-battery. This trouble is almost entirely the result of neglect. If the instructions which come with every battery are carefully followed, and excessive loads are avoided, any good battery should last five years or more.

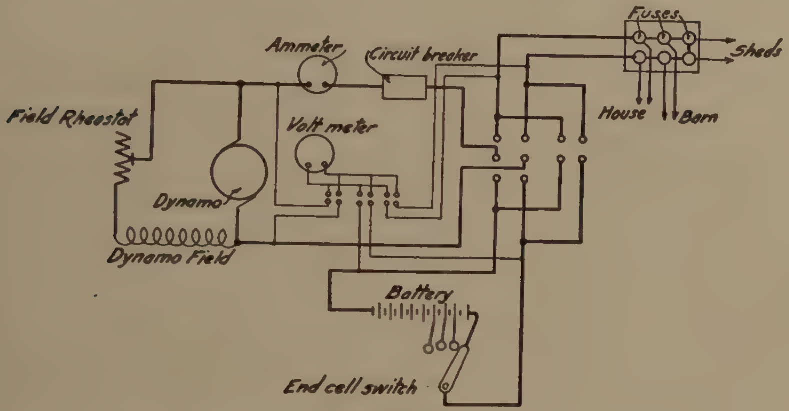


FIG. 216

System of switchboard wiring for the farm lighting plant. (Courtesy University of Minnesota.)

The better makes of storage-battery have a life of about 350 cycles. That is, such batteries may be charged and discharged once a day for a year. It is very seldom that any battery is called upon to render any such service. The chief causes for battery failure are sulphatization, due to standing in a partially discharged condition, overloading, impure water, and charging at too high a rate. So-called

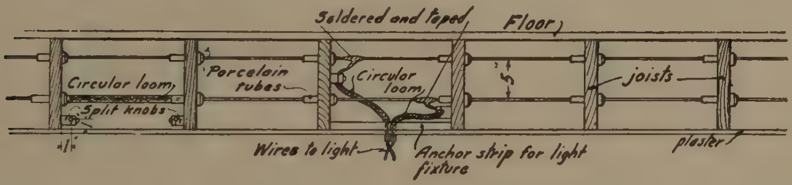


FIG. 217

Installation of electric wires in the joists of a building. (Courtesy University of Minnesota.)

rejuvenators are usually not only worthless, but actually harmful to any battery, no matter what its condition may be.

The capacity of any storage-battery gradually decreases with age and use. This process is perfectly natural and cannot be avoided. Each time a battery is charged or discharged, a certain amount of the active material on the plates is thrown off and settles to the bottom as a sediment.

There are a number of things which the owner or operator of a lighting plant should know. He should know that under certain conditions low-voltage current is more of a fire hazard than the usual one-hundred-and-ten volt current. He should know that it is not economically possible to use distribution lines more than 200 feet long. He should know that a storage-battery is never, under any farm conditions, more than 75 per cent efficient, and very seldom that. He should realize that his possibilities for power are very limited, and that his cost per unit will seldom be lower than high-line cost per unit. He should realize that the results obtained will be in direct proportion to the attention given the plant.

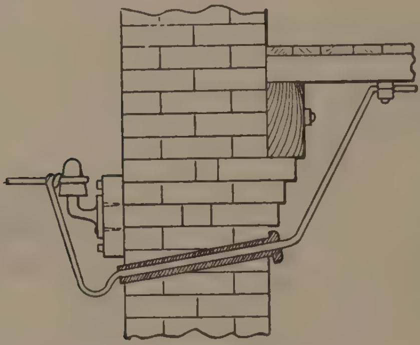


FIG. 218

Installation of wire through the wall of the building to prevent water from following the wire through. (Courtesy University of Minnesota.)

Some details of installation are shown in Figures 216, and 217, and 218.

References.

Wiber, W. B., *Electrical Construction*, Manual Arts Press, Peoria, Illinois, 1916.

Daniels, A. M., "Electric Light and Power from Small Streams," *United States Department of Agriculture Year Book*, 1918, p. 221.

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CHAPTER XIX

HEATING

Dwelling-houses and other human habitations are artificially heated for two reasons: comfort and health. By far the greater number of homes in the United States have to be heated during at least part of the year. If the principles involved were better and more generally understood, a greater amount of comfort could be obtained for a much smaller sum of money.

There is no universal remedy for all heating troubles. In general, unsatisfactory results are the result of three things: carelessness, ignorance, and too careful saving of fuel.

Carelessness may be the fault of the manufacturer of the heating outfit, the man who installs it, or the operator.

Lack of information on the part of the salesman, the installer, or the operator, and frequently of all three, is the cause of much trouble.

Too careful saving of fuel on the part of the owner is probably the cause of a great many of the ordinary troubles.

The kind of heating plant to buy depends on several things, namely, length of heating season, minimum temperature to be contended with, kind of fuel to be burned, and experience of the operator.

Heating season. A heating plant suitable for a house in the northern part of the United States would be entirely out of place in a locality where the temperature seldom goes below 50°. In such places, the heating season is usually quite short. It would not be wise to put in an expensive and bulky heating plant to provide for a few weeks of moderately cool weather, when an air-tight stove would suffice.

Minimum temperature. One of the things that a good heating plant must do is to keep the house warm under any and all conditions. In order to do this, it must be large enough to meet the requirements imposed by the lowest temperature likely to be experienced. It is not necessary, nor is it advisable, to have a heating plant large enough to do its work easily at all times. It is better and cheaper to put in a smaller heating plant and force it for a few days during extremely cold spells. A heating plant is most efficient when it is operated at its rated capacity. It is not always possible so to operate it, but good judgment will prevent the installation of a plant much too large or much too small.

Fuel. Some heating plants are designed to handle one kind of fuel, while others are more efficient when a different kind is burned. For example: the base-burner stove is an efficient heater when hard coal is used, but it will not burn wood satisfactorily. It is sometimes possible to make minor changes, such as in grates or arrangement of dampers, and thus to handle successfully fuel that the heater was not intended to burn.

Experience. It sometimes happens that a heating plant gives good service when taken care of by one person, but will not work satisfactorily for another. If the same kind of fuel is used, the trouble is very evidently with the operator. A few people never seem to be able to learn how to operate a heating plant to the best advantage. As a matter of fact, this trouble is almost always due to carelessness. It is generally caused by failure to do some of the things that should be done, such as closing or opening the dampers at the proper time. Under some circumstances, neglect of this kind is very dangerous.

Types of heating plants. Dwelling-houses are heated by fireplaces, stoves, or furnaces, or a combination of two or all of these. The proper plant for a house is largely a matter of personal preference.

An efficient arrangement must

1. be dependable.
2. be efficient.
3. not cost too much.
4. be clean; that is, free from gas and soot.
5. respond quickly.
6. burn several kinds of fuel.
7. take up little room.
8. provide adequate humidity.
9. be easily handled.
10. not freeze when left alone.
11. not be dangerous to handle.
12. be long-lived.

JOB 91

THE SELECTION AND INSTALLATION OF A FIREPLACE

House heaters may be roughly divided into three classes: those which heat mainly by radiation, such as fireplaces; those which heat by radiation and convection, such as stoves; and those which heat by convection, such as furnaces of all kinds.

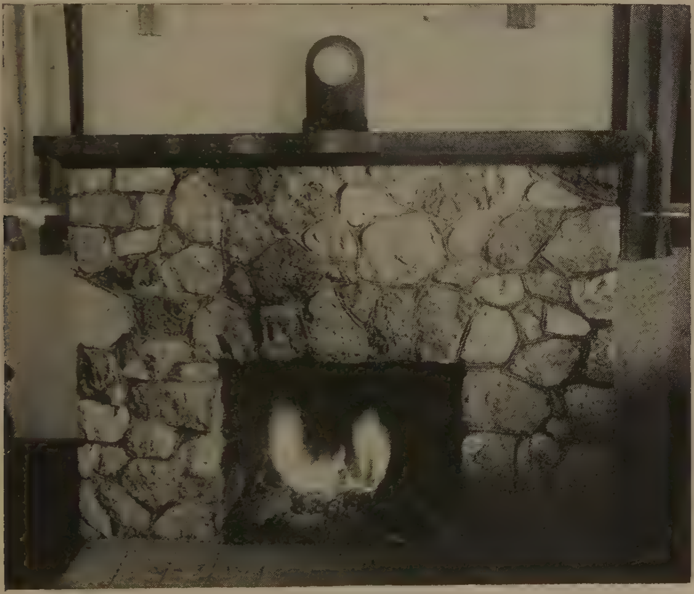


FIG. 219
A good type of fireplace. (Courtesy University of Minnesota.)

Fireplaces are little used now as primary heating plants. In the days when fuel was to be had for the cutting, the fireplace was fairly satisfactory. When fuel became more expensive, some better and more efficient means of heating had to be developed. The fireplace is a very inefficient heating device, as a large part of the heat goes up the chimney. The modern fireplace or grate, as it is sometimes called, is kept more for sentimental reasons than for its efficiency as a heating unit. See Figure 219. It is very pleasant to sit before an open fire, but this pleasure should not be lessened by having a smoky fireplace.

Procedure.

1. There are many efficient ways of building fireplaces. Each fireplace should have an independent smoke flue. This flue should be large enough to handle the smoke and gases; eight inches square in cross-section is usually deemed sufficient. See Figure 220.

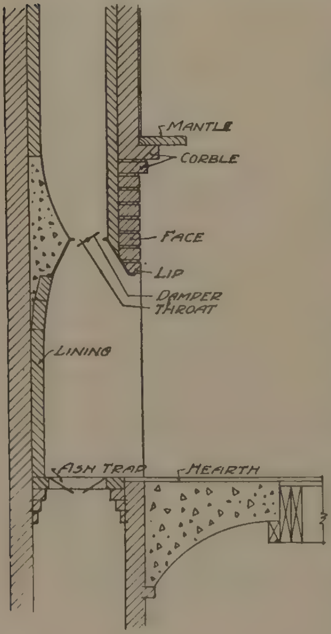


FIG. 220

Principles of fireplace construction. (Courtesy University of Minnesota.)

2. There should be some sort of a damper for closing the smoke flue when there is no fire or when ventilation is not wanted.

3. Perhaps one of the most desirable features of a fireplace is the ventilation which it affords. If the chimney is properly built, that is, higher than the ridge of the house, there is little likelihood of down drafts.

4. For safety's sake there should be a lining of firebrick, and the chimney flue should also be lined.

5. Smoking is the chief fault of many fireplaces. This trouble can be entirely eliminated by proper construction. It is always advisable to have the smoke enter the flue as near the front or breast as possible. See Figure 220.

It sometimes happens that there is little draft in the flue. It may be that the flue is cold, or that there are doors or windows open in such a way that there is actually a lower air-pressure in the house than outside. The first trouble can sometimes be remedied by thrusting a lighted newspaper up the flue and creating an artificial draft; this will warm the flue and produce a natural draft.

This remedy should never be applied when the roof is dry or when the burning paper may set fire to adjacent buildings or anything else inflammable. The second difficulty may be overcome by temporarily opening a door or window on the windward side of the building. As soon as a strong natural draft is established there will generally be no further trouble.

JOB 92

THE OPERATION OF HEATING PLANTS

1. *Stoves.* There is little to be said about heating stoves that is not quite generally known. As with every other manufactured article there are good, bad and indifferent stoves. The average person is hardly qualified to choose a good stove rather than a poor one, for the reason that the two may look nearly or even exactly alike; or perhaps the poorer of the two may have more nickel or ornamentation, and thus appear the better of the two. Quality in stoves depends more on material and workmanship than on appearances. It is generally safer to buy the product of some well-known concern which has a reputation to sustain than to invest in a stove in which quantity predominates over quality.

Reduced to simplest terms, a stove is a receptable in which fuel is burned. It must be provided with proper dampers and a suitable ash receiver. The style and type of grate is also of utmost importance. It is obviously impossible for any manufacturer to equip a stove in such a way that it will handle all fuels equally well. Wood burners work best with one kind of grate, while coal stoves require another type. Perhaps the safest plan to follow is to go to a reliable dealer, tell him what you want, and then take his advice.

To handle any stove properly requires a general knowledge of the use of the dampers or drafts, as they are sometimes called, although in reality the draft is the air which passes through the dampers. There are usually three dampers: (1) the lower or ash-pit damper, for admitting air to the under side of the fire; (2) the check damper, usually in the fire door, to admit air over the fire; and (3) a damper in the smoke pipe to prevent all of the heat from going up the flue.

Heat is obtained from any kind of fuel by causing or aiding the oxidation of the fuel. The more rapidly the oxidation takes place, the more quickly the heat is produced. When the lower damper and the pipe damper are both open, a strong draft of air passes through the stove and a brisk fire results. The temperature of the flue gases will be very high and much of the heat will go up the chimney. If the pipe damper is closed or nearly closed, the combustion will take place in the stove, and not in the chimney, where it would be wasted. After the fire is well started, it should be controlled almost entirely by means of the lower damper. In burning certain kinds of fuel, such as green wood or soft coal, it is advisable to admit a certain amount of air over the fire to insure thorough combustion. If air is not admitted over the fire, there is a tendency for the fuel to distil, with the result that the inside of the stove will be covered with creosote or tar oils, depending on whether wood or coal is being burned.

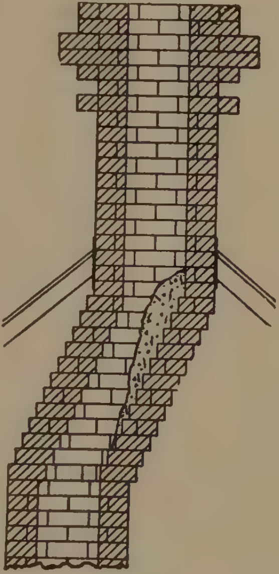


FIG. 221
Undesirable chimney construction.

2. *Furnaces.* Practically everything that has been said about stoves will apply equally well to what is commonly called a furnace. The modern furnace is simply a stove placed in the basement to get it out of the way. The dampers are handled in exactly the same way except that they sometimes are taken care of automatically by some sort of a mechanical device actuated by a thermostat. The chief difference between a stove and a furnace is that the stove heats by radiation and convection, while the furnace heats by convection only.

It is usually assumed that heat is transmitted in three ways: by radiation, by conduction, and by convection. If one end of an iron rod is placed in a fire, the other end becomes warm by conduction, the transfer being all in the iron. If we stand in front of an open end fire, we are warmed by radiation; that is, the heat energy leaves its source (the fire), passes through some medium (the air), and strikes some object (our bodies). Convection is the process by which heat is carried from one place to another by currents or moving particles of some substance. Air and water are the two mediums most used.

Procedure.

1. *Providing for effective draft.* In order to obtain an effective draft in a heating plant, it is necessary that the chimney be properly constructed.

a. The chimney should have a straight flue. When a turn in the flue is made, there is a greater possibility that mortar or other material will settle, as is shown in Figure 221. It is evident that this reduces the draft.

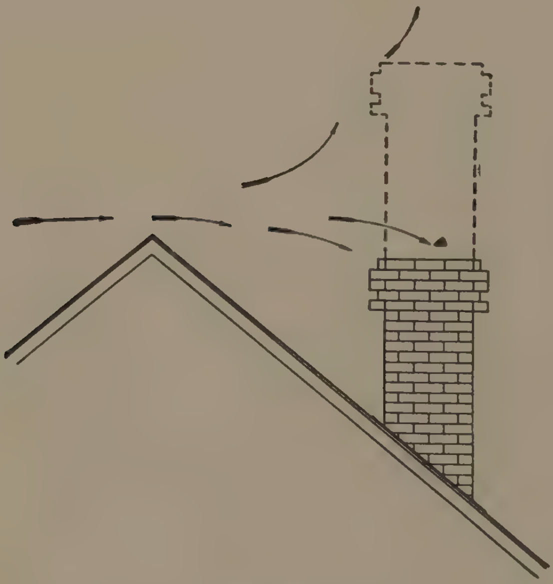


FIG. 222
Chimney too low.

b. Some chimneys will not provide draft when the wind is in certain directions. If the chimney is otherwise properly constructed, the difficulty is probably due to cross-currents developed because the chimney is not high enough. The remedy is shown by the dotted lines in Figure 222.

c. Another cause of trouble in the chimney is the leakage of air through its walls, as shown in Figure 223. This condition also reduces draft. The defective chimney may be repaired by plugging the leaks with mortar.

d. To insert the pipe to the chimney too far into the flue, as found in Figure 224, will cut down the amount of draft available for the fire. Care should be taken to avoid this defect in the chimney. See Figure 224.

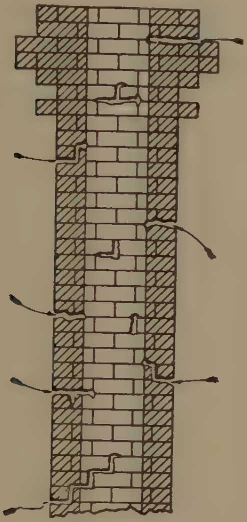


FIG. 223

Leakage of air in walls of chimney.

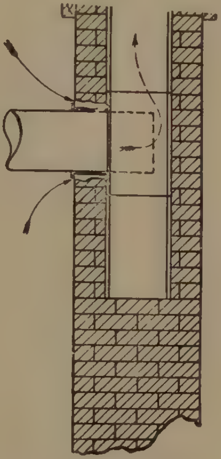


FIG. 224

Smoke pipe pushed too far into the flue.

e. Another little-noticed cause of reduction of draft may be found in a leaky flue stop which has rusted through or dropped out of place. The clean-out door may also be a source of leaks if it does not shut tightly, or if the packing around it is defective. See Figure 225.

2. *Handling the fire.* There are a few general rules which apply to all heating plants.

a. In the first place, if furnaces are being considered, get one that is large enough so that it will not have to be forced except in extreme weather.

b. Find the best fuel available and stick to it. Not a little trouble is occasioned by changing from one fuel to another.

c. Take care of the plant at regular intervals and do not slight it.

d. When a steady fire is wanted, as in winter, the firebox should be kept full of fuel. The directions that come with most furnaces say, "Keep the fuel bed as high as the level of the bottom of the fire door."

e. The size of the fuel has some bearing on the amount that can be put in at a time. There should always be some bright fire showing so that the gases which are formed may be ignited. If a large quantity of fine fuel, such as pea coal for instance, is put on a fire at one time, the fire will be partially smothered. A great deal of gas will accumulate above the fire and in the flue and may cause an explosion if ignited. It is better to add fuel a little at a time and at short intervals until the fire-pot is full. Some people fire alternately on one side of the fire-pot and the other, always leaving some bright fire to ignite the gases. Other firemen accomplish the same result by throwing the fuel as far back as possible and allowing it to slope to the front.

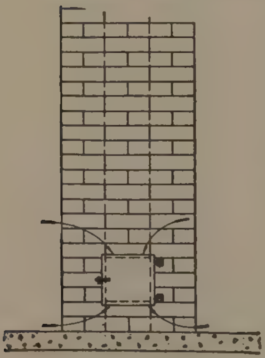


FIG. 225

Openings around clean-out door of the chimney.

f. Before putting on a fresh charge of fuel, it is advisable to level off the fire somewhat so that there will be little probability that holes will form in the fire bed. If these holes do develop, the incoming air will pass through them rather than the fuel bed. This particular fault is very largely responsible for the clinkers that are formed. Clinkers are made up of fused ash and foreign material. If the fire becomes thin in spots, there is less resistance to the draft in these spots, hence a higher rate of combustion and a higher temperature. Clinkers are always a sign of too high a rate of combustion. The nature of the fuel has a great deal to do with clinkering. The more foreign material in the fuel, the more clinkers. Wood never forms clinkers.

3. *Humidity.* The amount of moisture or water vapor in the air of an artificially heated house has a large bearing on the comfort and the cost of operation of the heating plant. Normal outdoor air contains varying amounts of moisture, depending on the season, the geographical location, and the time of day. For the northern half of the United States, where the heating problem is of utmost importance, the moisture content of outdoor air seldom goes below 50 per cent and is more often about 65 per cent of its maximum.

The actual quantity of water vapor present in the air at any time is very small. For instance, the weight of one cubic foot of saturated water vapor at the temperature of 68° F. is about one-thousandth of a pound, or roughly one drop in volume. If the saturation is only 50 per cent, the weight and volume are only one-half as much as the above. Thus, in an average-sized room under normal conditions, there is less than an ounce of water vapor.

Nearly everything with which we have to do contains more or less water in one form or another. If any of these things are put into a room in which the moisture is deficient, they tend to dry out, but if the moisture content is increased, they will absorb moisture. Human beings and other living things are affected in the same way. For example, when we go into a room which is warm and dry, the perspiration, which is always present in our bodies, tends to evaporate more quickly. In the process of evaporation, heat is absorbed. Consequently, we feel chilly. If the amount of water vapor in the room is increased, or, as it is generally stated, if the relative humidity becomes greater, there is less evaporation and we *feel* warmer even though the temperature may be lower.

The amount of moisture in the air is also important from the health standpoint. A large proportion of the minor ailments to which human beings are subject are respiratory in their nature or at least in their inception. One of the functions of the nasal passages is to prevent the entrance of dust particles and bacteria into the lungs. This is accomplished by the mucus which, under normal conditions, is always present in these passages. If the air that we breathe is lacking in moisture, the tendency is for this mucus to become hard and dry, and in this state it will not serve its purpose.

4. *Ventilation.* Heating and ventilation ordinarily go hand in hand, because when heating is not necessary, ventilation is not necessary either. This condition does not apply to large indoor gatherings, but is true for individual homes.

The best that can ordinarily be done in the way of ventilation is to maintain a degree of air purity inside equal to that out-of-doors. Sometimes it is desirable to wash or otherwise purify air and perhaps humidify it as well, but the expense is seldom warranted except in large halls or industrial plants. Air purity is at best a relative term, since the composition varies rather widely with the location. The term "pure country air" is usually used for comparison. Such air will contain about 20.9 parts of oxygen (O), 79 parts of nitrogen (N), .03 parts of carbon dioxide (CO_2), and traces of other gases. Carbon dioxide is one of the products of combustion. On an average, an adult will exhale about .6 of a cubic foot of carbon dioxide (CO_2) per hour. This gas, while not an active poison, is ordinarily used as an index of the purity of the air. Whenever the CO_2 content exceeds .15 per cent (fifteen parts in 10,000) the air is dangerous to breathe. A candle flame is extinguished before the CO_2 content reaches 3 per cent. In those states having ventilation laws for school buildings, from 1,800 to 2,000 cubic feet of fresh air (air containing not more than four parts of CO_2 in 10,000) are required for each pupil per hour. This is equal to thirty or more cubic feet per minute, and is supposed to maintain a CO_2 content of not more than seven parts in 10,000.

Artificial ventilation is seldom necessary in dwelling-houses. There are always cracks around windows and doors, and the building material itself is more or less porous. Under normal conditions there are about two complete air changes per hour in the average house.

JOB 93

SELECTION OF A HEATING PLANT

1. *Steam.* In many respects, steam heat is very desirable. It is quick, clean, and offers some opportunity for getting moisture into the air. The radiators are or may be somewhat smaller than those used in hot-water or vapor heating, because of the higher temperature of steam. This high temperature is liable to be something of a drawback, as the room temperature near the radiator may be considerably higher than elsewhere. The steam heating system has one inherent disadvantage and that is that the radiators are either hot or cold; there is no half-way point.

2. *Vapor.* The vapor system is essentially a steam system operated under a lower pressure. The temperature of steam from water boiling in an open dish is 212° F. at normal atmospheric pressure (14.7 pounds per square inch). If the pressure is lowered, the boiling-point is also lowered. For example, if the atmospheric pressure can be lowered to ten pounds absolute (4.7 pounds below atmospheric pressure), the boiling-point will be about 194° F.; if the atmospheric pressure is lowered to five pounds absolute, the temperature is 163° F.

In either a steam or a vapor system, there must be no leaks. With steam, the leak is always outward; while with vapor, the leak is inward. Vapor radiators never have air valves, while steam radiators always do unless there is a condensation pump to take care of the air and condensed steam.

Vapor systems are more flexible than steam systems, owing to the lower temperature at which the vapor is formed. The inlet valves on vapor radiators are generally arranged so that the whole radiator may be heated, or only a part of it, as desired. Steam is lighter than air, and if only a little is admitted, the upper part of the radiator only will be heated. Thus the heating surface of the radiator may be adjusted to weather conditions.

3. *Hot water.* In a hot-water system, like that shown in Figure

226, the water circulates from the furnace through the house and returns, when cool, to the furnace. A complete circulation system is necessary. Allowance must be made for the expansion of the water. Where an open tank is used, the plant will require larger pipes because of the increase in water necessary to heat the house. If the expansion tank is closed tight, there is a small amount of air compressed because of the expansion of the water in heating. This makes a semi-steam system. The closed expansion tank requires a higher temperature before the boiling-point is reached, which accounts for the fact that smaller pipes are required in the installation.

4. *Precautions in using steam, vapor, and hot water.* There are a great many ways in which steam, vapor, and hot-water systems may be installed, but none of them will be successful unless certain fundamental principles are observed. The heater and radiators must be large enough so that forcing is not necessary in ordinary weather. The pipes must be large enough, particularly in a gravity system such as a hot-water one. It is seldom advisable to use pipes smaller than the tappings in the heater.

All pipes should pitch or drain toward the heater; there must be no pockets to obstruct the free flow of steam or water. If conditions are such that pockets are unavoidable, they should be led back to the boiler by separate pipes. Branches to the various radiators should not be taken off the top of the heating main, for if they are, the first radiator will get the most heat. Radiators should be located against the outside walls, preferably under the windows.

In hot-water systems, some provision must be made for the expansion of the water. The expansion tank should be located where it will not freeze.

There is some difference of opinion as to the desirability of leaving the water in a system the year around. Some people prefer to drain in the spring and refill in the fall. Various reasons are offered for this practice, one of them being that fresh water is more "lively" than stale water. This probably is an error, and even if it is not, the advantage gained by changing water is not worth the bother. If the pipes are left full of water, little or no rust will form on the inside of them because the air has been driven out by the water and rusting takes place only when air or oxygen is present. In steam systems, the

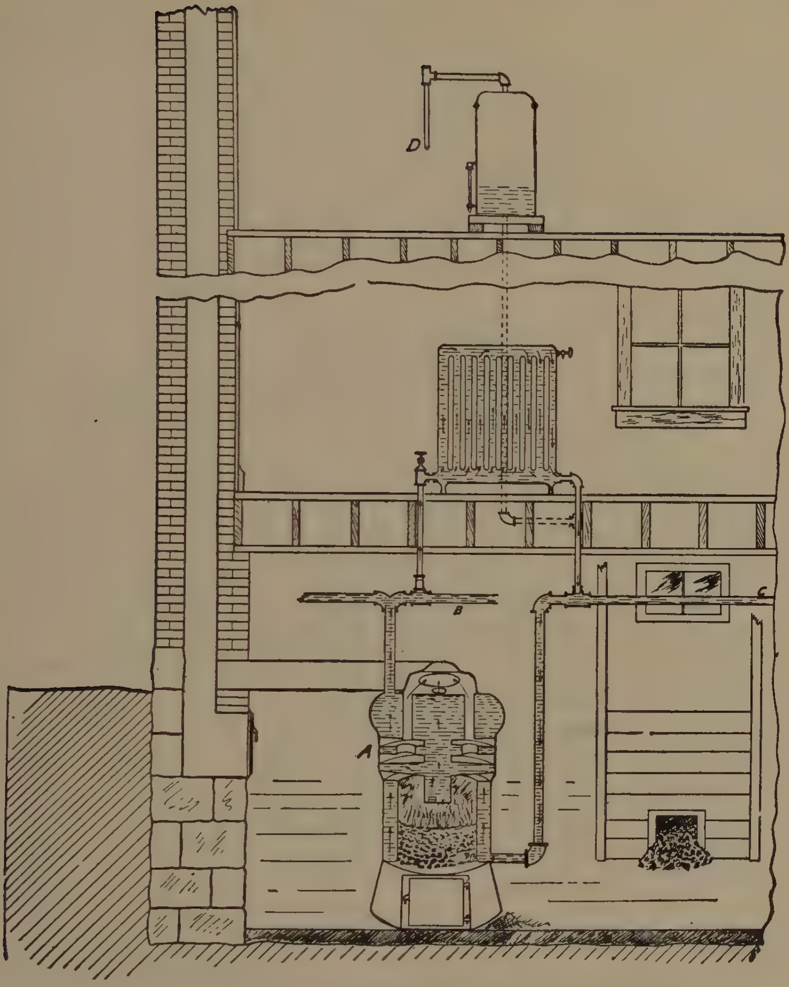


FIG. 226

Hot-water heating system. (Courtesy University of Minnesota.)

lime in the water is precipitated by boiling, and if no fresh water is added, no more lime can be thrown down to form scale. In steam systems in particular, it is advisable to add as little fresh water as possible.

With steam or hot water, it sometimes happens that the radiators will not heat. This is usually due to the presence of air in the radiators. Various air vents are used; some are merely petcocks to be operated by hand, while others permit air to pass, but close automatically when steam or water appears.

The matter of painting radiators is one which comes up quite frequently. A painted radiator is less effective than one which is not painted, but the difference is so slight that it is hardly worth consideration. The heat obtained from a radiator is directly proportional to its surface. A rough cast-iron radiator has more surface than one which is made smooth with paint. A gloss paint likewise is smoother than a flat paint. Tests have shown that color has some little bearing on the heating qualities of radiators, but the difference is so slight as to be negligible in most cases.

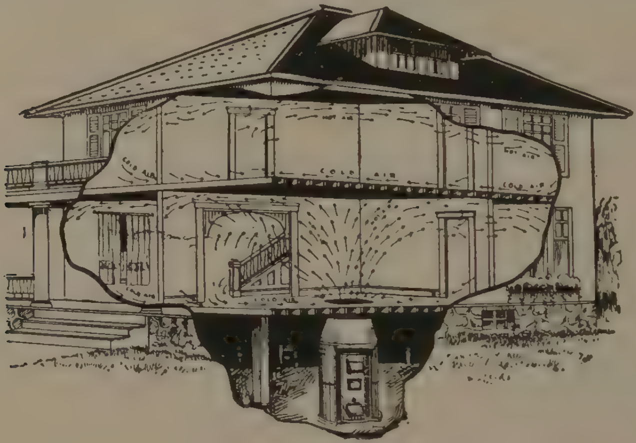


FIG. 227

Warm-air furnace. (Courtesy Andrews Heating Company.)

5. *Warm-air furnaces.* A warm-air furnace is nothing more than a special kind of a stove enclosed in a jacket and placed in the basement. See Figure 227. Under some conditions resulting from *improper* installation, a warm-air furnace becomes a hot-air furnace.

As with steam and hot-water plants, the heater is located in the basement and the heat is conducted to rooms above by air circulation.

In this type of heating plant, cold or cool air is admitted to the lower part of the furnace casing, is warmed by contact with the heater, and rises, because warm air is lighter than cold air. The principle is exactly the same as that which makes the draft in a chimney.

There are many ways in which furnaces of this kind can be put in, but in general there are two classes of installation: pipe furnaces and pipeless furnaces. Any heater may be made into either of these types by different methods of installing.

The *pipe furnace* is so called because the warmed air is conducted through pipes from the furnace bonnet to the rooms above. There is usually at least one warm-air pipe to each room to be heated. Cold or cool air is taken from out of doors or from the floors of the heated rooms. In the latter case, the plant is said to be recirculating. The cold-air intake from out of doors is gradually passing, owing very largely to the increased cost of fuel. It is much easier and cheaper to heat cool air than it is to heat extremely cold air from out of doors. It is undoubtedly true that better ventilation can be had with an out-door cold-air flue than by recirculation; nevertheless, the recirculating system has practically eliminated the out-door air flue. In some states recirculation is prohibited in school-houses and other public buildings if the heater is of the warm-air type. These same states, or some of them at least, permit steam or hot-water heat without fresh-air inlets.

The efficiency of any warm-air heater depends on an adequate cold-air inlet at the bottom of the furnace and ample means of getting the warmed air to the rooms where it is wanted. If the air passages are large and unobstructed, the heater will deliver a large volume of warm air; but if the pipes and ducts are small, a smaller volume of hot air is the result. It is sometimes said that the air smells scorched. This odor is due to the scorched dust particles in the air rather than to the air itself. If the furnace is installed properly, there never will be such an odor, as it will be impossible to heat the air hot enough to scorch anything.

The pipeless, or more properly, the one-pipe or one-register furnace, is a revival of an old heating principle. The action is as follows: The air around the heater is warmed and passes up through the register. This causes the cold air on the floor to travel toward the outside of the register.

Heaters of this type are quite efficient, fairly cheap, and easily installed. They are particularly adapted to large rooms such as schoolrooms, churches, and stores. It is unreasonable to expect such a heater to maintain an even temperature throughout a large house when the doors are small and there is no other means of circulation. Very few manufacturers will guarantee to heat such a house to an even temperature throughout. Many people prefer to sleep in cool or cold rooms, so the heating of the bedrooms is not a feature. A two-story house can be quite successfully heated by such a furnace if the stairway is large and open. Ceiling registers sometimes help, but they may serve as cold-air outlets under certain conditions. The most serious drawbacks in the use of this kind of heater are its inability to heat isolated rooms, such as bathrooms, and the necessity for leaving the doors open in order to heat all the rooms.

The pipe furnace differs from the pipeless type in that the heat is conducted from the heater to the various rooms by pipes of suitable size. The cold air is also taken from the rooms by means of pipes.

The chief operating difference between pipe and pipeless furnaces is that closed or isolated rooms may be heated with a pipe furnace, but not with a pipeless one. The only difference in cost between the two types depends on the amount of extra material and labor required to put in a pipe furnace. The difference in results obtained depends on the way the installation is made.

The most common error in pipe-furnace installations is a restricted air circulation. This fault may be caused in a number of ways; the pipes, either for warm or for cold air, may be too small; they may be too long; they may be too nearly horizontal; or they may be so crooked as to make the air friction very great. Both warm air and cold-air registers may be too small, or located in wrong places.

Air circulation in any closed room is caused by the difference in weight between cold and warm air. This difference is so slight in ordinary cases that the least obstruction greatly retards the flow. For example, the difference in weight between a cubic foot of air at 50° F. and the same volume at 125° F. is about one-quarter ounce. Assuming that these temperatures are about right for the incoming and outgoing air, the amount of draft is plainly very small. Long, straight stacks, particularly those to second-floor rooms, always deliver more air for any given cross-section than shorter ones.

JOB 94

ESTIMATING SIZE OF HEATING PLANT REQUIRED

General information.

There are a great many ways of figuring heat losses, appropriate size of a furnace, size of pipe, and radiator sizes. There is no rule or formula which will fit all cases. Because of the many variables to be met, it is a common practice, particularly in home installations, to assume the most adverst conditions possible and put in a heating system of sufficient size to overcome them.

Of necessity, the manufacturers of heating equipment make only a few sizes. It is good practice to purchase a furnace a size larger than the required rating for heating the house. For example, the maker rates the capacity of a certain heater at 10,000 cubic feet and the next larger at 14,000 cubic feet. With the most careful figuring, it is found that a particular building contains 11,321 cubic feet to be heated. The furnace with a capacity of 14,000 cubic feet should be installed. The reason for this is that the rating put on a furnace is the rating secured under ideal conditions. This means that the fuel is of the best quality and the furnace is operated by an expert. The results secured under these conditions cannot be duplicated with the average home-operated furnace. The larger furnace will require less forcing and may be operated at a lower cost.

Procedure.

Note.—The following directions or rules are offered as a guide in selecting and installing a suitable heating plant.

1. *Warm-air heater.* Find the cubic contents of the room or rooms by multiplying together the length, width, and height, all measured in feet.

Find the total exposed glass surface, figuring all openings the full size and assuming outside doors to be all glass.

Find the total outside wall area (less the glass surface) and reduce to an equivalent glass surface by dividing by 10, if the building is of good wood construction.

One square foot of glass or its equivalent, ten square feet of outside wall, will cool seventy-five cubic feet of air per hour.

The total air to be heated per hour is:

$$\text{Volume in cubic feet} + \left\{\frac{\text{wall area}}{10} + \frac{\text{glass area}}{10}\right\} \times 75.$$

To obtain the diameter in inches of the warm-air pipe to each room, multiply the cubic feet to be heated per hour in that room by the factor .012.

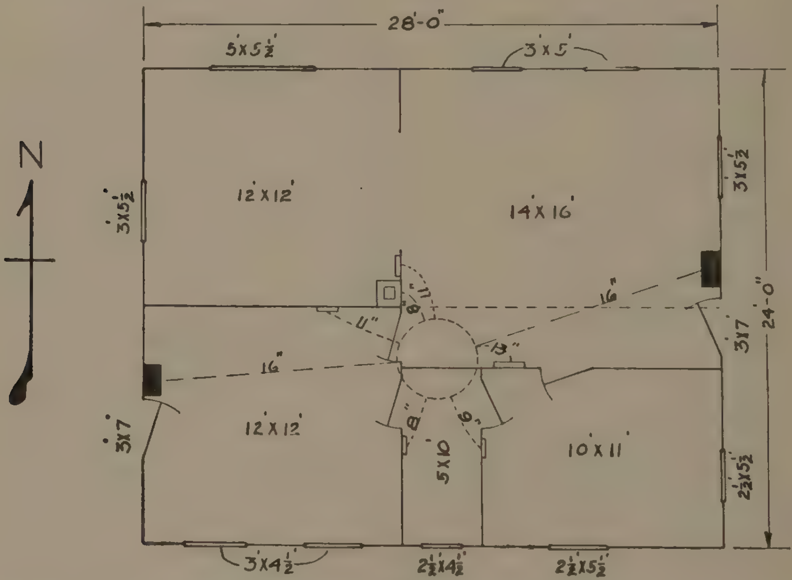


FIG. 228

Floor plan of a bungalow used as a basis for estimating the size of heating plant required.

For each degree below zero, add 1 per cent to the heat requirements.

2. *Hot-water heater.* One square foot of glass area equals one square foot of radiation.

Ten square feet of outside wall area equals one square foot of radiation.

Seventy-five cubic feet equals one square foot of radiation.

3. *Steam heater.* Use two-thirds as much radiation as for hot water.

4. *Application of house-heating rules.* Figure 228 represents the floor plan of a bungalow with four rooms and a bath and with nine-foot ceilings. It is of good frame construction, the attic is floored, and there is a basement under the whole house. The windows are single glass (no storm sash). The inside temperature is to be 70° F. and provision is to be made for 20° below zero. The house faces east, with north and west exposures. All rooms are to be heated. The following calculations are designed to illustrate the application of the above rules in selecting and installing desirable and adequate heating facilities.

TABLE 3

Calculations for Warm-Air Heating

Bungalow, four rooms and bath	*Room 1 (living)*	*Room 2 (bed)*	*Room 3 (bath)*	*Room 4 (kitchen)*	*Room 5 (dining)*	*Totals*
(1) Glass area in sq. ft.	70.5	27.5	11.25	48	44	201.25
(2) Outside wall less glass ÷ 10 = equivalent glass	19.95	16.15	3.38	16.8	17.2	73.48
(3) Volume in cubic feet	2,016.00	990.00	450.00	1,296.00	1,296.00	6,048.00
(4) (Glass + equivalent glass) × 75	6,783.75	3,273.75	1,096.88	4,860.00	4,590.00	20,604.38
(5) Cubic feet of air to be heated per hour [(3) + (4)]	8,799.75	4,263.75	1,546.88	6,156.00	5,886.00	26,652.38
(6) Cubic feet [(5)] × .012 = area of round warm-air pipe in sq. in.	105.597	51.165	18.56	73.87	70.63	
(7) Add 1% for each degree below zero (20°—)	21.119	10.233	3.71	14.77	14.13	
(8) Cross-sectional area of warm-air pipe in sq. in.	126.716	61.398	22.27	88.64	84.76	383.79
(9) Computed diameter of warm-air pipe	12¾"	8⅞"	5⅜"	10⅝"	10⅜"	
(10) Actual diameter of warm-air pipe	13"	9"	8"	11"	11"	
(11) Diameter of cold-air pipe	16"			16"		
(12) Furnace recommended: 18" fire Pot.						

Calculations for Hot-Water Heating

(1) Glass area in sq. ft.	70.50	27.50	11.25	48.00	44.00	201.25
(2) Outside wall less glass ÷ 10 = equivalent glass	19.95	16.15	3.38	16.80	17.20	73.48
(3) Volume in cubic feet ÷ 75	26.88	13.20	6.00	17.28	17.28	80.64
(4) Sq. ft. of radiation required [(1) + (2) + (3)]	117.33	56.85	20.63	82.08	78.48	355.37
(5) Heater recommended: 16" grate diameter.						

Calculations for Steam Heating

Heater recommended: 16" grate diameter.

Note.—The steam and hot-water boilers are somewhat larger than necessary, but are the smallest made.

CHAPTER XX

WATER

Pure water is a combination of the two gases hydrogen and oxygen in the proportion of two of the former to one of the latter. It is never found "pure" in nature, but always contains other things which may make it unfit for human consumption. Every school-boy is familiar with the water cycle: (1) evaporation from ground, lakes, trees, and nearly every other object in the open air; (2) condensation in the upper air into clouds; and (3) rain, snow, or hail, which return the moisture to the earth.

Whenever water evaporates, it leaves behind all foreign substances and is pure. As an invisible vapor, it rises and comes in contact with various impurities in the air such as smoke, dust particles, and flower pollen. With it falls as rain, it carries down these various substances and retains them until they are filtered out by the passage of the water through some fine material, such as earth.

As the water percolates through the soil, it leaves behind most of the foreign material it has picked up in its descent from the clouds, but acquires other substances from the soil or rocks through which it passes. Water is an excellent solvent, and has some effect on practically everything with which it comes in contact. The substances most commonly formed are the carbonates, chlorides, and sulphates of various elements, and organic compounds of vegetable or animal origin.

Pure water, therefore, is merely a relative term used to indicate water that has a high degree of purity. It implies water that is relatively free from color and odor and that has not been contaminated by any undesirable mineral, organic. or bacterial materials which make it objectionable for ordinary use.

COMMON PROPERTIES OF WATER AND THEIR CAUSES

The most common properties of water and their most common causes are as follows:

Hardness or "hard water" is due largely to the presence of the carbonates and sulphates of calcium and magnesium.

Soft water is water that is relatively free from the carbonates and sulphates of lime and magnesium.

Turbid or *cloudy* water is "dirty" because it has suspended in it a quantity of matter such as fine clay, sand, or silt.

Impregnated water is water which contains in solution such chemicals as iron, sulphur, lime, and other elements to the extent of making it undesirable for the ordinary uses of water.

Putrid water is water contaminated with organic matter, sulphur, iron, or other materials to the extent that it has a disagreeable odor or taste or both.

Polluted water is water which has been contaminated by excreta from animals or is otherwise made objectionable by being mixed with undesirable foreign materials.

Colored or stained water indicates the presence of extracts from organic matter, usually of vegetable origin.

Infected water is water which contains disease-producing germs. It may be similar to polluted water, or it may have the appearance of being pure.

JOB 95

SELECTION OF A WATER SUPPLY

Procedure.

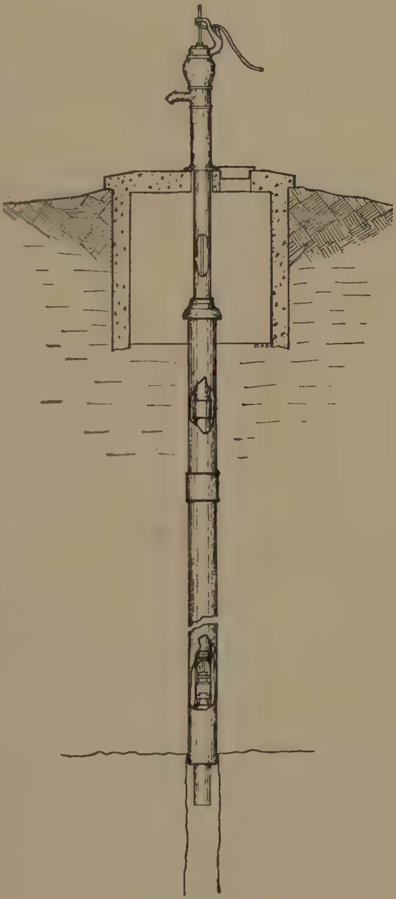


FIG. 229

The cased well is a good type of well. (Courtesy University of Minnesota.)

Water is of two kinds, namely, ground and surface water. In general, ground water is obtained from wells of various depths, is usually hard, and is usually safe to drink. Surface water is that obtained from streams, lakes and some springs. It is usually soft, has some color and taste, and is looked upon with suspicion unless filtered or otherwise treated. Individual farms are almost universally supplied with ground water, while large towns and cities depend on treated surface water.

There are at least three ways in which ground water may be contaminated or polluted. If the earth formation happens to be of limestone, there will be open passages or channels in the rock which will permit the passage of germs from some surface source. The water may be contaminated by seepage from some outbuilding or barnyard. The most common way in which ground water is contaminated, however, is the

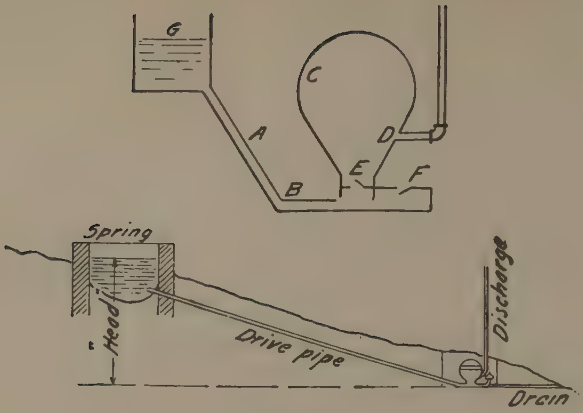


FIG. 230
Principles of installation of a hydraulic ram. (Courtesy University of Minnesota.)

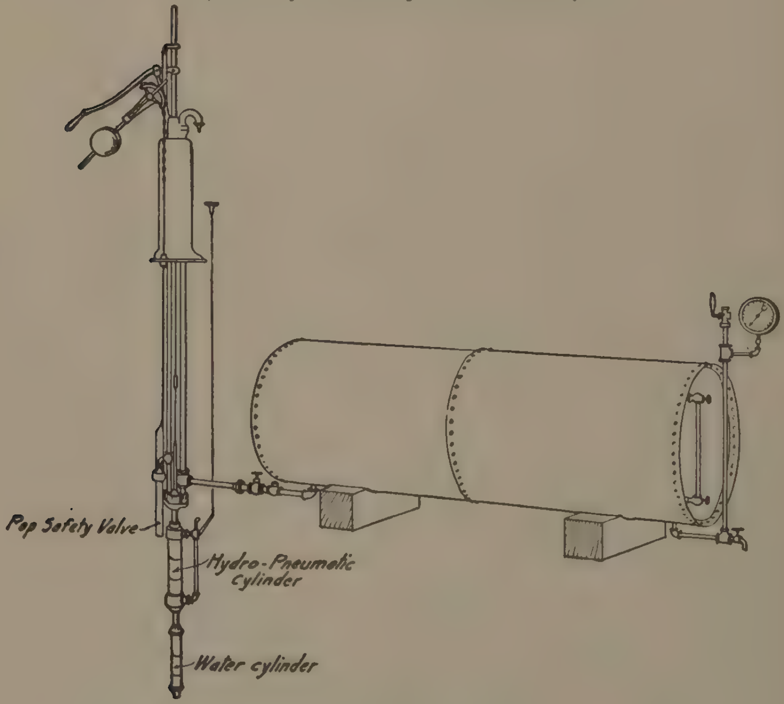


FIG. 231
A type of pressure system for use on the farm. (Courtesy University of Minnesota.)

entrance of foreign material into the well from the top. The latter condition can be remedied only by making the well tight at the top.

Every dug well should have a concrete curb and platform. The curb should extend downward as far as necessary, and at least a foot above the ground level at that point. It is never advisable to use plank for well curbing. Stone, brick, concrete, or vitrified tile is usually cheaper in the long run. If the well is of the drilled or driven type as shown in Figure 229, the pipe or casing should extend above the ground and have a concrete collar to prevent surface water from washing down outside the pipe. If it is necessary to make a well in a low spot, the ground surface should be so graded that surface drainage is away from and not toward the well.

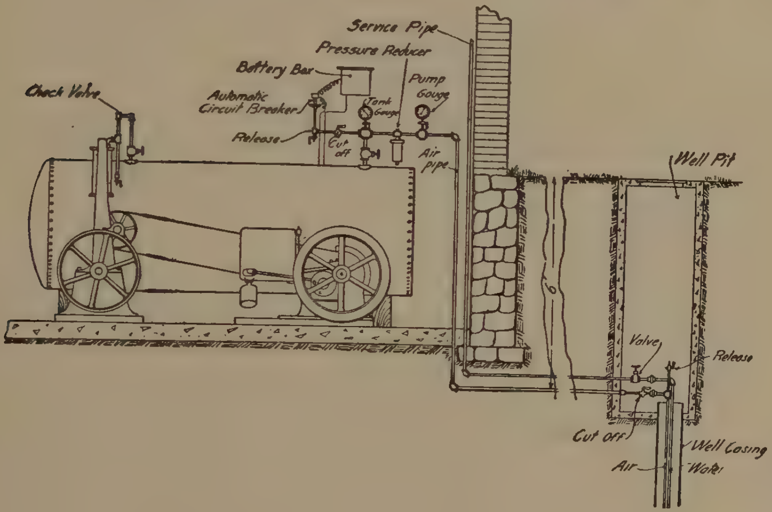


FIG. 232

The pneumatic system. (Courtesy University of Minnesota.)

A spring, if used as a source of domestic water, should always be protected by a concrete or a brick curb and a metal or a concrete cover.

One of the greatest needs in the average farm home is running water. There is no other single thing which will so reduce farm-home drudgery. No other thing has so great an effect on the health and welfare of the farm family. No other farm improvement returns such large dividends on the money invested as does running water.

There are so many ways in which running water may be obtained at little expense that there is no excuse, in the majority of cases, for not having it.

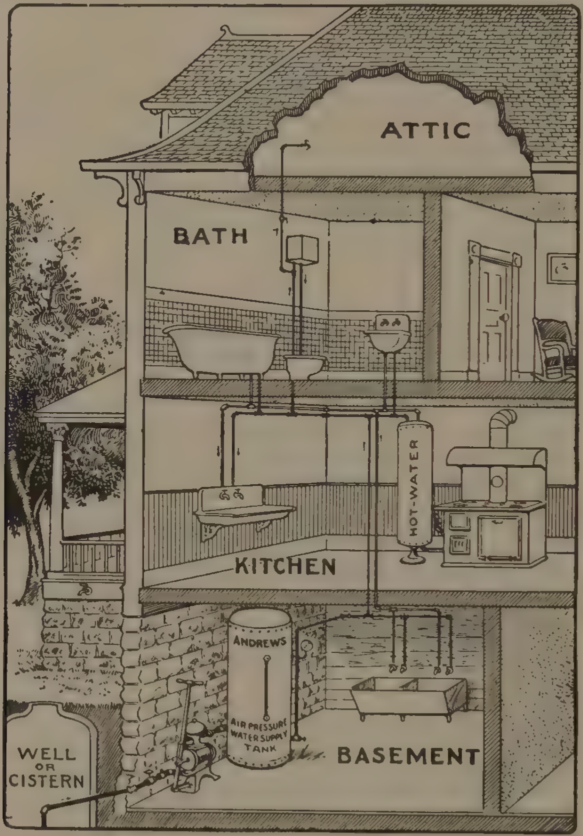


FIG. 233

Hand-power pressure system. (Courtesy Andrews Heating Company.)

In rolling country, a high spring may make it possible to pipe the water directly to the house and barn. A small stream may permit the installation of a hydraulic ram. See Figure 230. The windmill usually is practical, and may be used with a pressure system as shown in Figure 231. Electric and gas-engine power are widely used. See Figure 232. Until the other power is available, hand force-pumps offer a solution. See Figure 233.

References.

Stewart, John T., *Engineering on the Farm*, Rand, McNally & Co., Chicago, Illinois, 1923.

Twillinger, Robert W., "Clean Water and How to Get It on the Farm," *United States Department of Agriculture Year Book*, 1914, p. 101.

CHAPTER XXI

RURAL SANITATION

Sanitation may be considered as the removal or neutralization of elements injurious to health.

One of the most important sanitation problems on farms is the proper disposal of human waste. The most common method of disposal is the out-door privy. Buildings of this kind may serve the purpose with little or no offense, but they are usually neglected and become sources of disease. Where an outside privy is to be used, Job 96 suggests the construction of a desirable type.

A more desirable means of sewage disposal is a sewer system. Where running water is available, a satisfactory disposal system is easily installed.

One of the common methods of sewage disposal in use is the cesspool. The cesspool is simply a hole in the ground from which liquids seep away into the soil and in which the solids are retained. If the soil is porous the cesspool has often proven satisfactory for years, but more often the cesspool clogs and it is necessary to provide a new one. Where dish-water, wash water, bath water, and human excreta are to be disposed of together, the cesspool is not satisfactory.

The *septic tank* provides a more satisfactory method of sewage disposal. The sewage that is carried into a septic tank furnishes food for a number of different types of bacteria. As the bacteria act upon this sewage, decomposition takes place, and the solid substances, as well as organic compounds in solution, are broken down. The bacteria multiply rapidly at warm temperatures, but multiply and act very slowly at low temperatures. These types of bacteria thrive best when the amount of oxygen present in their habitat is limited. This means that the sewage should enter the tank without carrying in a large amount of air. During the decomposition of the organic matter, several gases, including methane and hydrogen sulphide, are formed. These gases are enclosed within some of the solid matter and make it buoyant enough so that it floats. This, with the grease and other light matter, forms a scum over the surface of the liquid in the tank. This scum excludes light and oxygen from the active bacteria below. The sewage there will be made up of several types of matter which will not be decomposed. This material, consisting of non-putrescible substances like mineral matter and carbon, together with some lower forms of animal and plant life, forms a sludge at the bottom of the tank. The liquid between the scum and the sludge is quite free from large particles of suspended matter. This liquid should be discharged from the tank. About one-half to three-fourths of the suspended solids taken into the tank are left as scum and sludge or decomposed, and the rest is carried out in the effluent.

A septic tank will not operate where used for disposal of wash water and dish-water only. The bacteria in the tank must have food. However, if the water from the tank flows out on top of the ground, the soap-suds will simply be carried through the septic tank. If the tank effluent is dispersed in tile, the use of soap-suds alone will clog the tile.

The statement is sometimes made, and believed by many, that the effluent from a septic tank is clear and pure. This is far from the truth. Under certain conditions the effluent may be fairly clear, but it is *never* pure. The action which goes on in a septic tank is primarily one of liquefaction and gasification. Disease-producing bacteria or germs may or may not be killed; as a matter of fact, they seldom are harmed to any great extent. The action that goes on in the tank, while very necessary, is entirely preliminary to the action in the soil. If the system is such that the effluent is not diluted by being emptied into a body of water, it must be discharged into or onto the soil for the final nitrification and oxidation process.

JOB 96

CONSTRUCTION OF A SANITARY PRIVY

Material and equipment.

Hammer; saw; framing-square; level; keyhole saw; screwdriver; hand ax.

Skids—two pieces 8″ log 6′6″ long; floor, seat-front, roof boards, door—130 sq. ft. 1″ x 6″ D. & M.; drop siding—150 sq. ft.; joists, rafters, studding, plates—180 linear ft. 2″ x 4″; trim—80 sq. ft. 1″ lumber; seat and covers—16 sq. ft. (pine); sash and glass for two windows 8″ x 12″; hinges—five pair of 2″, one pair 3″ spring for door; one rim-lock or thumb latch; roofing—one roll of composition or two bundles of shingles; vault—50 sq. ft. rough lumber.

Procedure.

1. Select a location where there is no possibility of contamination of well water.

2. Select a location where the privy will be accessible in severe weather.

3. Plan the location so that a screen of shrubbery may be planted. This will prevent the building from becoming an eyesore in the general plan of the farmstead.

4. The plan suggested (Figure 234) provides for screened windows, fly-proof construction, and a sturdy building which will not present a dilapidated appearance after a short period of use.

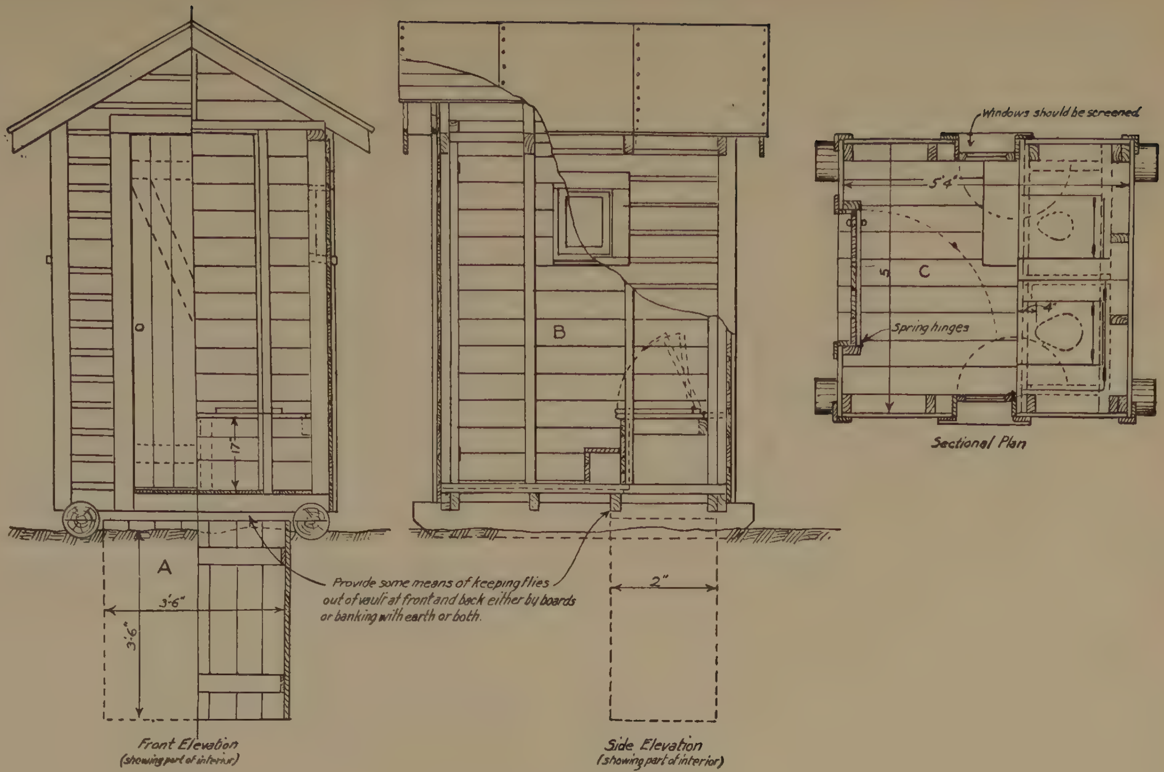

Windows should be screened
5'4"
C
5
4'
Spring hinges
Sectional Plan
B
A
17"
3'6"
3'6"
2"
Provide some means of keeping flies out of vault at front and back either by boards or banking with earth or both.
Front Elevation (showing part of interior)
Side Elevation (showing part of interior)

FIG. 234

Plan of a sanitary privy.

JOB 97

SELECTION OF A TYPE OF SEPTIC TANK

Procedure.

1. *Size of the tank.* In figuring septic-tank sizes, it is usual to assume that each person will use about thirty gallons of water per day. It is also usual to assume that the sewage should be held in the tank forty-eight hours. Under these conditions, a septic tank for a family of eight should hold 480 gallons. This would mean that the tank should have a volume, up to the water-line, of sixty-four cubic feet.

The tank must be large enough so that the accumulation of sludge during the wintertime can be handled. This is a special problem for the first winter, as very few tanks installed in the late summer get much bacterial action until the following summer. The proper size is best obtained by giving the tank sufficient depth. A deep tank has two other advantages. The sludge at the bottom will not be disturbed so much, and the tank will be kept warmer in winter by the earth below. The disturbing of the sludge does not interfere with decomposition; in fact, it may aid it, but it allows the sludge to be carried out into the drain tile.

2. *Design for aiding decomposition:*

a. Inlet: The inlet pipe must be so arranged as not to carry air down into the water in the tank. The incoming water must not stir up the sludge at the bottom. A single sewer pipe or sewer-tile elbow will keep the sludge stirred up. A baffle placed across the front of the inlet will not allow incoming sewage to stir up the sludge. A baffle wall should be placed fairly close to the inlet, as one placed a foot or so out from the end causes a very heavy scum to form around the inlet and in some cases may block it.

b. Outlet: The outlet pipe from the septic chamber should open sideways to prevent particles that are buoyed up by gas from going out of the chamber. This outlet should open somewhere near the half depth of the liquid. Neither a wooden baffle nor any other wood should be used if it is to project above the surface of the liquid. Wooden boxes for current-breakers may be used if entirely submerged. Some means should be provided for venting the tank, through either the outlet, or the inlet, or both.

In most sewage-disposal installations it is not feasible to run the tank effluent onto the ground. In cold weather it would freeze, and in warm weather it would create a nuisance because of its odors. The usual method is to discharge it into open-joint tile lines which are laid fairly close to the surface of the ground. The depth and length of these subsurface tile lines depends largely on local conditions. In general, the tile line should be in the upper three feet of soil, and of such length that one foot will handle one gallon of tank effluent. In heavy clay soils, two feet or more of tile per gallon may be necessary, while in coarse sand or gravel, one foot of tile may handle two gallons of sewage.

3. *Number of chambers to provide.*

a. The *single-chamber tank* may be used under some conditions. The single chamber will produce the decomposition necessary, but where the soil water-level is high, a drainage well must be provided to take the discharge from the tank.

If the water-level is low enough so that the discharge from the septic tank can be placed below the frost line, then a single-chamber tank may be used. However, this condition is not often found.

b. The *two-chamber tank* is the more satisfactory tank to construct. The second chamber is to provide for siphon action in the discharging of the tank. The siphon action provides for the discharge of eighty to 100 gallons of water within two or three minutes.

Rapid discharging has the advantage of minimizing danger of freezing at the tile outlet when the tile opens into an open ditch. Freezing would take place if the water came out slowly.

When a *tile disposal system* is used, the siphon system carries out the discharge at intervals, and this allows time for the soil to be aërated and the bacteria to continue the decomposition. If the siphon were not used, the land nearest to the tile would become water-soaked and decomposition would be stopped.

JOB 98

CONSTRUCTION OF THE SEPTIC TANK

(See Figure 235)

Material and equipment.

Five yds. concrete; reinforcing—168 ft. 1/4″ rods in four lengths; standard 3″ siphon; tile—number depends on soil and size of tank; proportions for concrete, 1-2½-5, or, if bank gravel is used, 1-6; cover slabs somewhat richer, 1-2-3 or 1-4; if bank gravel is used, 20 sacks cement and 5 yds. gravel will be required.

Procedure.

1. *Location.* Usually it is preferable to place the tank near the house, because waste in flowing a short distance does not become cooled as much as in flowing a long distance.

The tile may be placed nearer the surface without danger of freezing when the water is warmer.

The warmer water also allows for more rapid bacterial action.

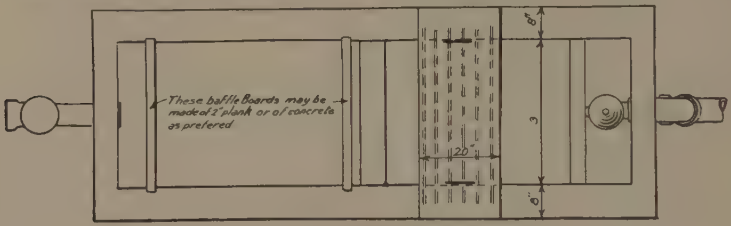
If the tank is close, iron soil pipe may be used from the tank to the house. Four-inch vitrified sewer tile is easier to install. The joints in the tile should be cemented tight. The tile should have a slope of about one to two feet in 100 feet of run.

2. *Excavating for the tank.* If the soil is of clay or sandy loam, outside forms will not be necessary, except at the ends where the inlet and outlet tiles are placed. The hole should be dug to provide for a wall four inches thick.

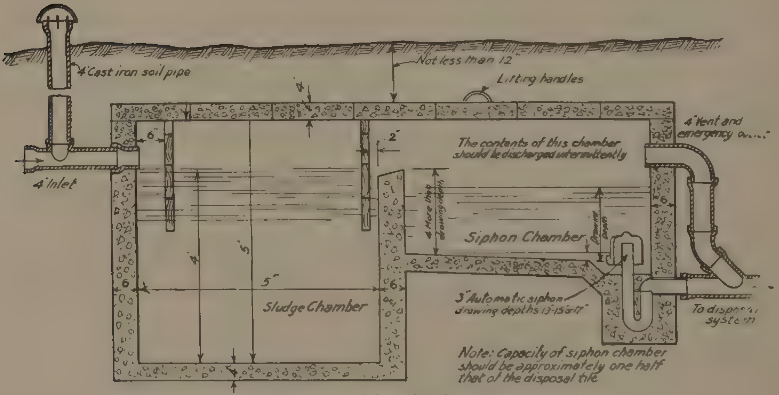
Where an outside form is unnecessary, the inside forms should be set in position as soon as possible after the hole is dug and the side walls made before caving starts. The floor may be made last.

3. *Forms.* The forms can be made of any rough one-inch lumber that is available. The forms should be made so that they may be easily removed. The boards for the forms may be nailed to two two by fours that are long enough to reach a foot or so

above the forms. These two by fours should be nailed on about two inches from the ends of the boards. Cut these form boards to run crosswise, and as long as the inside dimension of the tank. The boards for the side forms can be nailed to two one-inch strips in the same way, excepting that these boards will be two inches shorter than the length of the tank. The up-and-down cross boards will be nailed flush with the end of the boards for the side forms. Use sixpenny nails and do not clinch. Nail the boards firmly on the end forms; the side forms may be nailed sparingly. When the forms are put in place, they will lock at the corners and will need only a nail at the top and bottom to hold them together. The upright two by fours on the end forms hold the side forms;


These baffle Boards may be made of 2" plank or of concrete as prefered
8"
3
20"
6"

Plan (One cover slab in place)


4" Cast iron soil pipe
Not less than 12"
Lifting handles
4"
6"
2"
4" Inlet
The contents of this chamber should be discharged intermittently
4" Vent and emergency o...
4 More than drawing depth
Drawing depth
Siphon Chamber
4'
5'
5"
6
6
6
Sludge Chamber
3" Automatic siphon drawing depths 13-15 & 17"
To dispo... system
Note: Capacity of siphon chamber should be approximately one half that of the disposal tile

Section of two chamber tank for 4 people

FIG. 235
Plan for a concrete septic tank.

see Figure 236. Holes should be made in the forms for the tile and so on, so that the tile can be concreted in.

4. *Mixtures.* The concrete for the walls and floor should be mixed in about a 1-3 mixture if the gravel is fine, and a 1-4 mixture with coarse gravel. The mixture should not be sloppy, but comparatively dry. Spade it down next to the forms and tamp it firmly. Stones up to two inches in diameter may be used to fill in the wall. Wet all stones before putting them into the concrete. The concrete should not be exposed to the sun for a few days unless it is kept wet.

5. *Covers.* The cover is made of four-inch concrete slabs. Make these slabs of concrete mixed 1-3 with good gravel, and keep the mix dry. The forms may be made of two by fours placed on edge on a platform. Reinforce the covers with old iron. Place iron loops in each end for handles. Do not make the slabs wider than twenty inches. The slabs should be kept moist for a week after being made and should not be exposed to the sun.

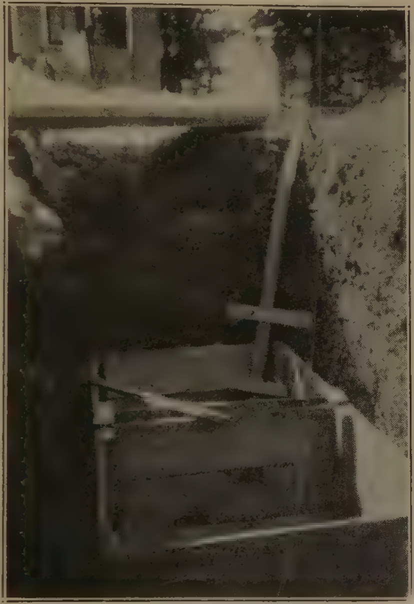


FIG. 236
Forms for a septic tank in place.

6. *Disposal tile.* The disposal tile, if a system of underground disposal is necessary, can be made of four-inch agricultural tile. See Figure 237. Use sewer tile with cemented joints from the tank to the disposal field, as in Figure 237. The amount of disposal tiling will be from 100 to 200 feet according to conditions. This tile should be laid on an even grade with open joints and covered with about two feet of earth. It may be necessary to

place drainage tile near the other tile and about one foot deeper to keep down the soil water.

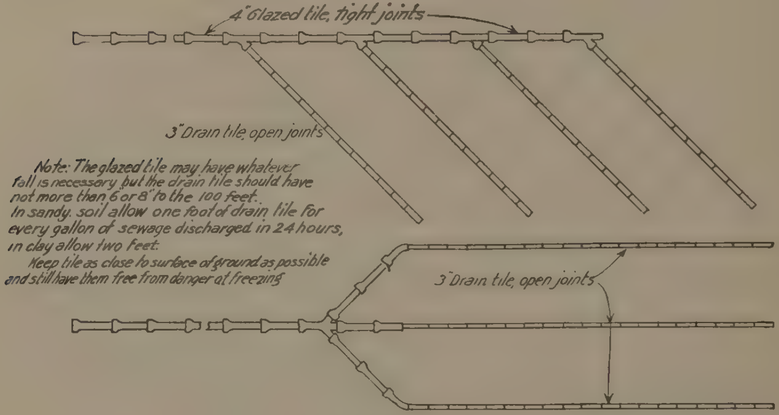

4" Glazed tile, tight joints
3" Drain tile, open joints
Note: The glazed tile may have whatever fall is necessary but the drain tile should have not more than 6 or 8" to the 100 feet.
In sandy soil allow one foot of drain tile for every gallon of sewage discharged in 24 hours, in clay allow two feet.
Keep tile as close to surface of ground as possible and still have them free from danger of freezing
3" Drain tile, open joints

FIG. 237

Two ways of laying disposal tile (not to scale).

7. *Operation of the tank:*

a. The system should be used continuously.

b. Care should be taken to see that there are no leaks in the water system which will flood the septic tank.

c. Keep out all grease that can be conveniently avoided.

d. Keep out acids, strong alkalies, and antiseptic solutions, for these will kill the bacteria in the tank.

References.

"Safe disposal of human excreta at unsewered homes," *United States Public Health Bulletin No. 68.*

Concrete Septic Tanks, Portland Cement Association, Chicago, Illinois.

CHAPTER XXII

ROPE AND ITS USE ON THE FARM

Practically every farmer finds it necessary to use rope in carrying on many of the activities of the farm. For this reason, information regarding the kinds of rope and its selection and care, and the ability to make simple knots and splices, should be of value to any one engaged in farm work.

Rope is made by twisting together the fibers of plants. The most common materials used in rope making are manila and sisal fiber. *Manila fiber* is obtained from the outer bark of the leaf stems of the abaca tree. The abaca tree is a species of the banana plant and is grown extensively in the Philippine Islands. The manila-hemp fibers vary in length from four to twelve feet and are very flexible and strong. Although "manila" usually indicates a superior quality in rope, it must be remembered that over a dozen different grades of manila rope are on the market.

Sisal rope is made from fibers obtained from the leaves of the henequen plant, which grows extensively in Yucatan, Mexico. The sisal fibers are from two to five feet in length and are weaker, heavier, harsher, and less flexible than manila fiber. Rope from sisal fibers is usually regarded as about three-fourths as strong as good-quality manila rope. The manila rope is white and the sisal rope is light brown in color. Short ends of fibers protruding from manila rope are usually an indication of adulteration with sisal.

Rope should be kept in a dry place, as moisture causes it to deteriorate and consequently decrease in strength. Tar or other oil preparations also tend to weaken the rope. If rope needs to be lubricated or protected from rain, ordinary beef tallow is probably the most satisfactory material to use. If rope becomes too stiff, it may be softened by boiling in water. Frequently new rope, especially if made from sisal, needs to be softened or made more pliable before it can be used to the best advantages. After being boiled, the rope should be stretched out and allowed to dry thoroughly before it is used.

STRENGTH OF ROPE

In figuring the breaking strength of rope, a good grade of manila is taken as a standard. The approximate breaking strength in pounds is found by squaring the diameter of the rope in inches and multiplying by 7,200. For example, the breaking strength of a one-half inch manila rope is found as follows: $\frac{1}{2} \times \frac{1}{2} \times 7{,}200 = 1{,}800$ pounds. It is safe to trust a rope with a load of about one-sixth of its breaking strength. The approximate safe load for a one-half inch manila rope is 300 pounds. Sisal rope is about three-fourths as strong as manila rope. This fact should be considered in calculating the breaking strength of sisal rope.

The following rope work is presented as representative of the "rope jobs" a farmer is likely to meet in performing ordinary farm work.

JOB 99

TO WHIP THE END OF A ROPE TO PREVENT THE STRANDS FROM BECOMING UNLAID

Material and equipment.

Rope; pocket-knife; ringer and rings; string.

A. Permanent Whipping

Procedure.

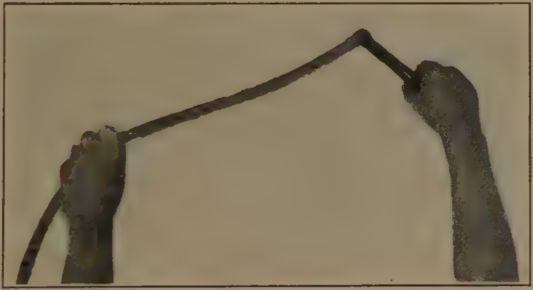


FIG. 238
Permanent whipping.

1. Put the ring in place in the ringer and close it down tightly over the end of the rope, as in Figure 238. It is better to put on two rings a short distance apart.

B. Temporary Whipping

Procedure.

1. Place the ends of the string along the end of the rope to be whipped, as in A, Figure 239.
2. Place the thumb on one end of the string at the point a and rotate the long part of the string around the end of the rope as in B, Figure 239.

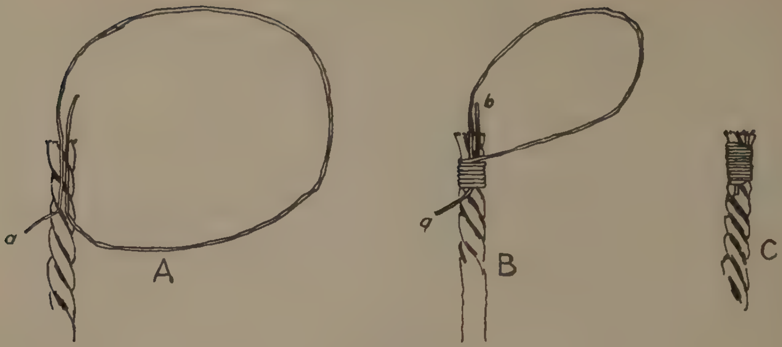


FIG. 239
Temporary whipping.

3. When the end of the rope has been sufficiently whipped, pull the two ends a and b tight and trim away the surplus string. C, Figure 239, shows the finished whipped end. This method of whipping is very good for use in temporary work, as it can be easily unlaid.

JOB 100

TO TIE THE WEAVER'S KNOT AND THE SQUARE KNOT

Material and equipment.

Five ft. ¼″ rope.

General information.

These knots are useful for joining ends of rope.

A. Weaver's Knot

Procedure.

1. Make an open bight as in A, Figure 240.

2. Put the other end of the rope through this bight from the bottom and draw it through for a distance of four or five inches as in B, Figure 240.

3. Rotate the free end around the shank of the bight and tuck the end of the rope under itself as in C, Figure 240.

4. Draw tight.

B. Square Knot

Procedure.

1. Cross the ends as in A, Figure 241.

2. Rotate one end of the rope around the other end as in B, Figure 241.

3. Again rotate one end around the other in such a manner as to bring both parts of one rope in front or behind the other as shown in C, Figure 241.

4. Grasp both strands and draw tight.

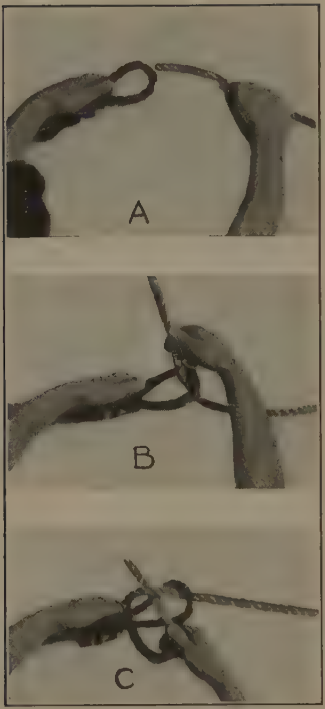


FIG. 240
Steps in making the weaver's knot.

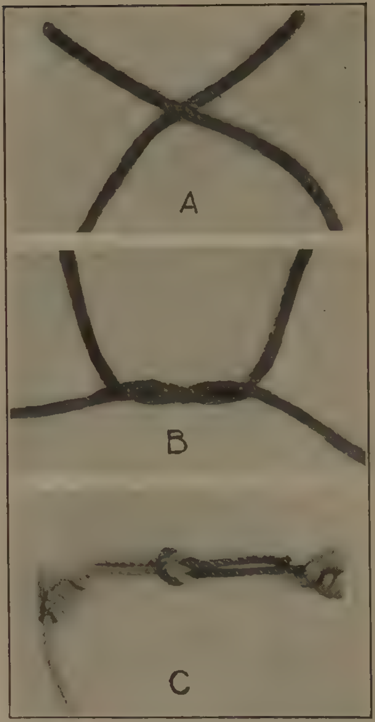


FIG. 241
Tying the square knot.

JOB 101

TO MAKE THE SLIP-KNOT AND HALTER TIE

Material and equipment.

Rope and any object about which the knot is to be tied.

General information.

These knots will draw tight on any object about which they are tied.

A. Slip-Knot

Procedure.

1. With the free end, make an overhand knot around the main rope, as in Figure 242.

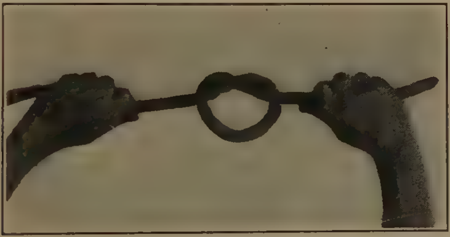


FIG. 242
Overhand knot.

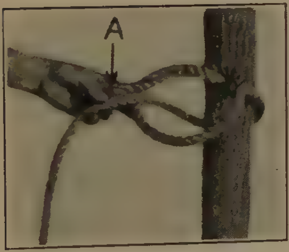


FIG. 243
The slip-knot.

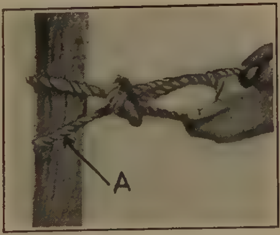


FIG. 244
The halter tie.

2. Draw the end A tight and the result is a slip-knot. See Figure 243.

B. Halter Tie

Procedure.

1. Proceed as with a slip-knot, excepting that the part A in Figure 244 is drawn through as a loop.
2. Stick the end A back through the loop to prevent the knot from becoming untied.

JOB 102

TO TIE THE BOWLINE KNOT

Material and equipment.

Rope and any object about which the knot is to be tied.

General information.

This knot forms a loop which does not slip or draw tight.

Procedure.

1. Make a closed bight, the main part of the rope lying on top.
2. Put the free end of the rope through the closed bight from the top side, bending it up and over the main rope as in A, Figure 245.

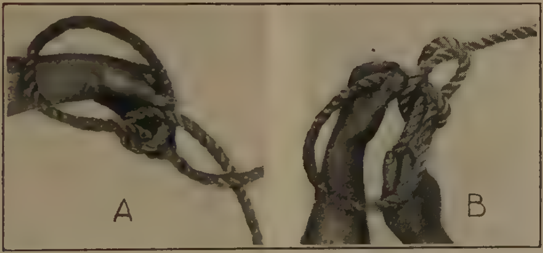


FIG. 245
The bowline knot.

3. Bring this end around the main rope and back through the closed bight, the end coming out in the same manner as it entered, as shown in B, Figure 245.
4. Grasp the loop of the rope with one hand and draw the rope tight with the other hand.

JOB 103

TO MAKE A WELL-PIPE HITCH AND A TIMBER-HITCH

Material and equipment.

Rope; iron pipe; timber if convenient.

General information.

The well-pipe hitch slides along the pipe easily in one direction but grips the pipe tightly when pulled in the other direction.

The timber-hitch grips the timber firmly, but can be quickly untied when the rope is let go slack.

A. Well-Pipe Hitch

Procedure.

1. Take three or four turns about the pipe as in A, Figure 246.
2. Half-hitch the short end of the rope around the long end as in B, Figure 246.

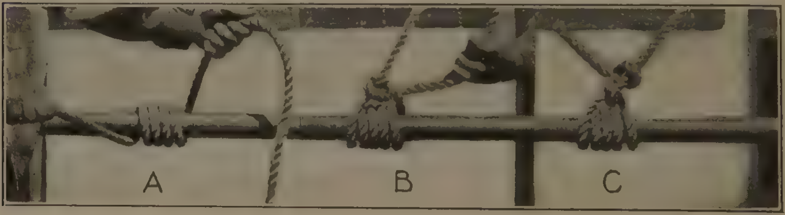


FIG. 246

The well-pipe hitch.

3. Make another half-hitch with the short end, as in C, Figure 246.
4. Draw on the long end to pull the rope tight.

B. Timber-Hitch

Procedure.

1. Wrap the rope around the timber.

2. Wind the rope around itself as in Figure 247 until three turns are completed.

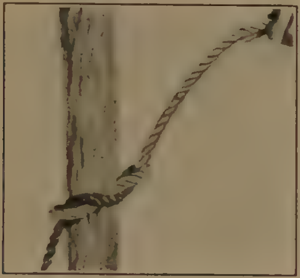


FIG. 247

Timber-hitch.

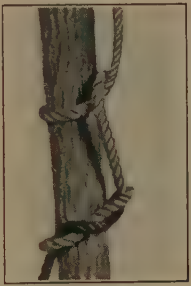


FIG. 243

Timber-hitch and half-hitch combined.

3. This completes the timber-hitch, but if it is necessary to tow the log or timber, make one or more half-hitches above the timber-hitch, as in Figure 248.

JOB 104

TO MAKE THE SHORT SPLICE, EYE SPLICE, AND LONG SPLICE

Material and equipment.

Twelve ft. ⅜″ rope or hay-fork rope.

General information.

The short splice is used to fasten two ends of rope together in cases where the increased diameter is of no disadvantage.

The eye splice is used in cases where a loop is desired at the end of a rope, as in the making of rope halters.

The long splice is used to fasten two ends of rope together where no material increase in the diameter of the spliced portion is desired. It is used especially for splicing hay ropes.

A. Short Splice

Procedure.

1. Unlay eight or ten turns of each strand of the two ends to be spliced.

2. Butt the unlaid ends together, being careful to alternate the strands so that each strand from one rope will lie between two strands of the other, as in A, Figure 249. The strand A lies between the strands B and C and the strand C between the strands A and D. Continue this procedure with the other strands.

3. Take a strand from each of the rope ends, as, for example, in B, Figure 249. The strand C of the rope from the left is brought over the strand D, coming from the right, then under it, and the resultant overhead knot is drawn tight.

4. Do this with each pair of strands, being careful that the strand from the left, which should be the nearer of the pair, is always laid over and then drawn under toward the front one. In this way the knot follows the twist of the strands and is the beginning of the splice, which is just a continuation of this wrapping procedure.

5. Tie all of the pairs of strands with an overhand knot as shown in C, Figure 249.

6. Open one of the strands of the rope next to the knots just tied and put the strand coming from the left through this opening.

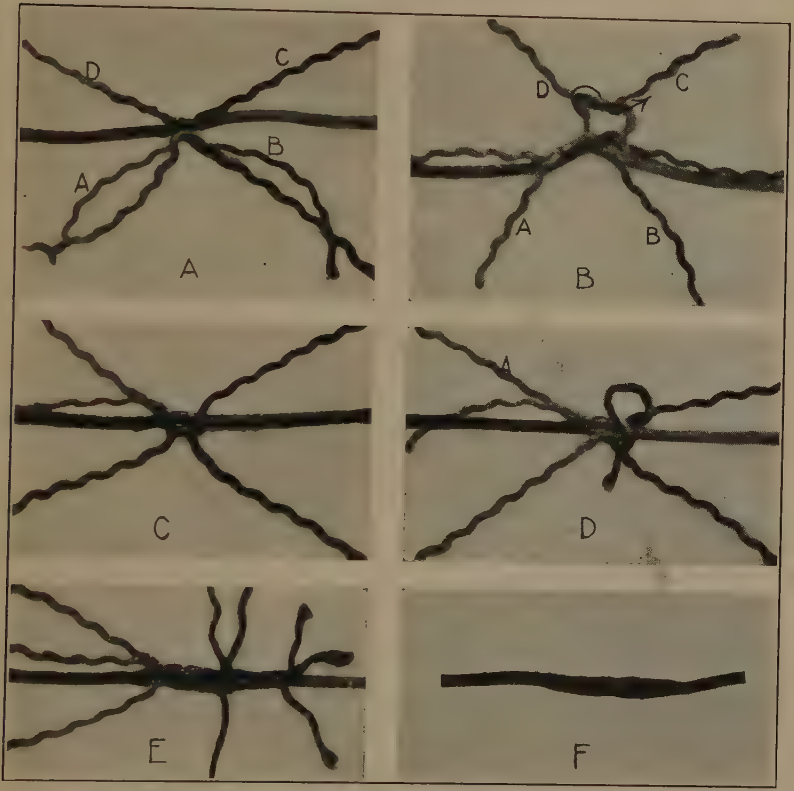


FIG. 249
Steps in making the short splice.

You will note that the strands A and B in A, Figure 249, have been tied together with an overhand knot and that strand B is tucked under strand A. Strand B is then given a clockwise twist and drawn tight. Do the same with the other two pairs of strands.

Give each of the strands coming from the left another turn, taking care to twist each strand tightly as it is drawn through.

7. Divide each of these strands in half.

8. Twist one half of each strand tightly and continue the splicing with these halves for two more turns as shown in E, Figure 249. The purpose of splitting these strands is to taper the splice.

9. Follow the same method in finishing the other half of the splice.

10. Cut off the surplus parts of each strand.

11. The finished splice should appear as in F, Figure 249.

12. Master this splice before attempting any of the other splices, because it is fundamental.

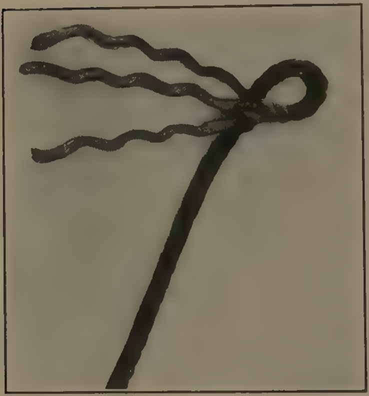


FIG. 250
The eye splice.

B. Eye Splice

Procedure.

1. Unlay the strands six turns.

2. Bend the end back on itself to form the size of the desired eye.

3. Open a strand of the main rope and insert one of the unlaid strands.

4. Open the next strand of the main rope and insert another one of the unlaid strands. Do the same with the remaining unlaid strand.

5. Draw all strands up tightly as in Figure 250.

6. Finish this splice exactly the same as you did the short splice.

C. Long Splice

Procedure.

1. Unlay the strands of both ends to be spliced for fifteen or twenty turns and butt the unlaid ends together in the same manner as for the short splice.

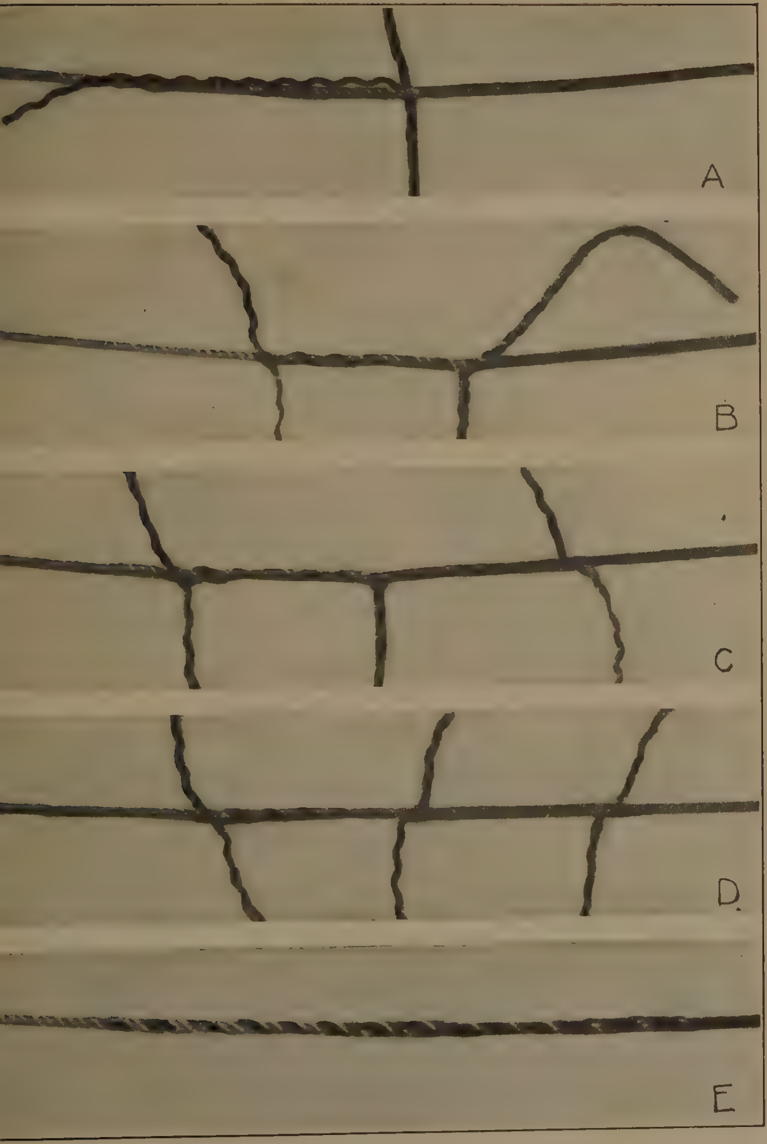


FIG. 251
The long splice.

2. Take one pair of strands and wrap them around each other anti-clockwise. Perform the same operation with the other pair of strands as in A, Figure 251. This will leave strands A and B lying along their respective parts of the rope.

3. Unlay strand A and follow it up closely with strand B, twisting it as it is laid in its new position. When there are about five turns left of strand A, tie an overhand knot with strand B as shown in B, Figure 251.

4. Perform the same operation with one more pair of the twisted strands, as shown in C, Figure 251.

5. Untwist the pair of strands that now remain in the middle of the splice and tie an overhand knot with them, as shown in D, Figure 251.

6. Finish each of the pairs of strands which have been tied in overhand knots the same as you did in the short splice. The finished long splice should appear as in E, Figure 251.

JOB 105

TO MAKE THE DOUBLE-DRAW AND EMERGENCY ROPE HALTERS

Material and equipment.

For large stock use one-half inch rope twelve feet long. For small stock use three-eighth inch rope, eight to ten feet long.

General information.

The double-draw halter is adjustable and serves very well for permanent use.

The emergency halter can be quickly constructed for emergency use.

A. Double-Draw or Adjustable Halter

Procedure.

1. Make an eye splice in one end of the rope large enough to allow the end of the rope to pass through. See Figure 252.

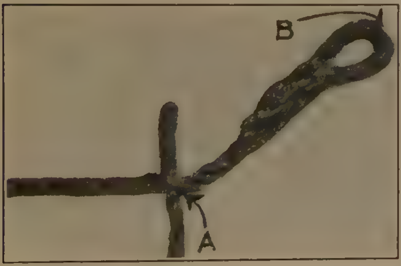


FIG. 252
Eye splice.

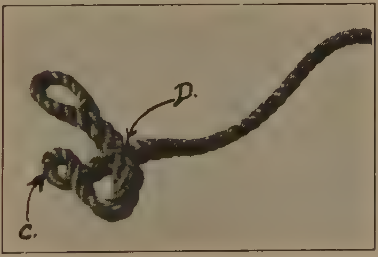


FIG. 253
Second step in making the adjustable halter.

2. Whip the other end of the rope.

3. At the proper distance from the eye, open one strand and insert the whipped end, as in Figure 252. The distance from A

to B will vary from twelve to sixteen inches, depending upon the size of the animal.

4. Draw the end through until another eye is formed, as shown at C in Figure 253.

5. Open the third strand of the main rope and insert the spliced eye as shown at D in Figure 253.

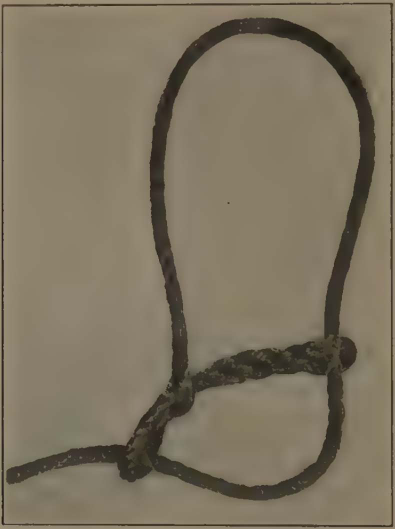


FIG. 254
The completed adjustable halter.

6. Draw the spliced end through snugly.

7. Pass the long end of the rope through the spliced eye, then across and through the spliced loop, and the halter is completed, as shown in Figure 254.

B. Emergency Halter

Procedure.

1. Tie a small bowline knot in one end of the rope. This end of the rope is thrown over the neck of the animal, the bowline knot reaching under the throat.

2. Pass an open bight (A, Figure 255) through the small bowline knot, then slip this loop up over the animal's nose. See Figure 256.

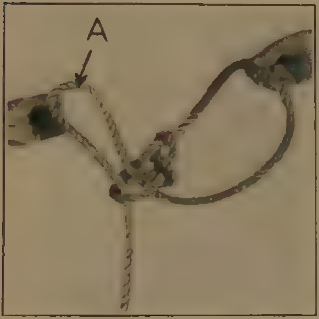


FIG. 255
Emergency halter.

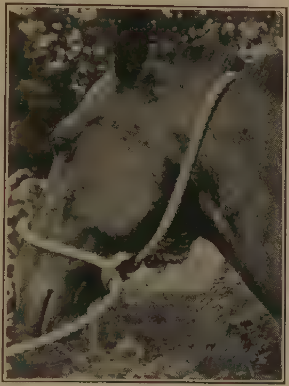


FIG. 256
Emergency halter in service.

To release the halter, simply push the loop off the animal's nose and draw on the main part of the rope.

JOB 106

TO MAKE A TEMPORARY KNOT IN A BROKEN STRAP

Material and equipment.

Broken strap; knife.

Procedure.

1. Through the center of one end of the broken strap cut a slit about one and one-half times the width of the strap, so that the end of the slit will be about two inches from the end of the strap.

2. Pass the end of the other strap through the slit and pass it around the under side to the top. Tuck the end under itself and draw it up tight.

3. Draw the knot tight by pulling on the strap on each side of the knot.

JOB 107

TO BREAK A HEAVY STRING OR TWINE

Material and equipment.

Strong twine, such as binder twine.

Procedure.

1. Wrap the twine once around the hand as in A, Figure 257.

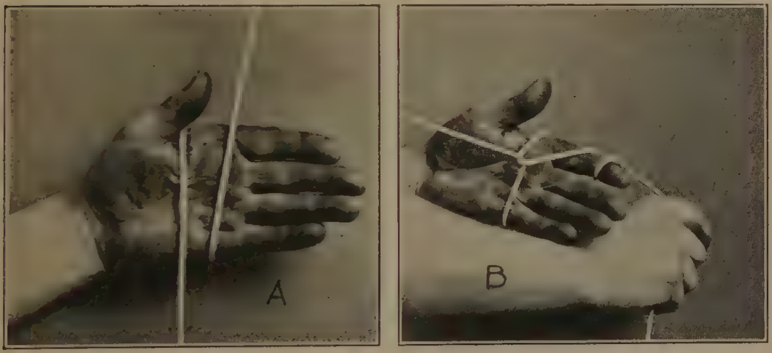


FIG. 257
Arrangement of string for breaking.

2. Cross the twine by bringing the lower end up to the index finger. In order to hold the twine firmly, wrap it around the index finger two or three times as shown in B, Figure 257.

3. Wrap the other end of the twine around the other hand and give the string a sharp jerk. The friction on the twine at the point of the crossing as shown in Figure 258 will shear it.

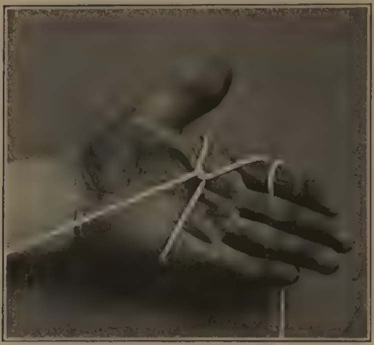


FIG. 258
String ready for breaking.

References.

Frear, J. B., "Rope and Its Use on the Farm." Bulletin 136, Agricultural Experiment Station, University of Minnesota.

Roehl, L. M., *Farm Shop Book,* Bruce Publishing Co., Milwaukee, Wisconsin, 1923.

Smith, Robert H., *Agricultural Mechanics,* J. B. Lippincott Co., Philadelphia, 1925.

APPENDIX

EFFECT OF GRADES ON THE EFFECTIVE DRAW-BAR PULL OF A TRACTOR

(By permission of International Harvester Company.)

For every 1 per cent rise in grade (a rise of one foot in every 100 feet of distance) the effective draw-bar pull of a tractor is lessened by 1 per cent of the weight of the tractor plus the weight of the load being drawn.

Roughly, for every 1 per cent rise in grade, the effective draw-bar pull is decreased at least 3 per cent.

SPEED OF CIRCULAR SAWS (CORD-WOOD)

(By permission of Henry Disston and Sons, Philadelphia.)

The peripheral speed (rim speed) of the saw should be approximately 9,000 feet per minute.

TABLE 4

Saw diameter	*R. P. M.*
8″	4,500
12″	3,000
16″	2,200
20″	1,800
24″	1,500
28″	1,285
32″	1,125
36″	1,000

SPEED OF TWIST-DRILLS (FOR GENERAL FARM SHOP WORK)

TABLE 5

Diameter of drill	*R.P.M.*
1/8″	1,000
3/16″	650
1/4″	500
5/16″	400
3/8″	325
7/16″	275
1/2″	245
5/8″	200
3/4″	160
7/8″	140
1″	125

The above table is based on a peripheral speed of approximately thirty-three feet per minute.

SPEED OF EMERY-WHEELS

Table 6

(By permission of David Maydole Hammer Company.)

Diameter	*R.P.M.**
3″	6,366
4″	4,775
5″	3,820
6″	3,183
7″	2,728
8″	2,387
10″	1,910
12″	1,592

* Based on peripheral speed of 5,000 feet per minute.

APPROXIMATE CARBON CONTENT OF STEELS USED IN THE CONSTRUCTION OF FARM TOOLS AND EQUIPMENT

Table 7

Mild steel, commonly called iron	.05% to .25%	(or 5 to 25 point carbon)
Machinery steel	.25% to .60%	(or 25 to 60 point carbon)
Tool steel	.60% to 1.30%	(or 60 to 130 point carbon)

For the construction of such tools as cold-chisels, punches, and similar tools, use 85 to 95 point carbon steel.

APPROXIMATE WEIGHT OF SQUARE AND ROUND IRON OR STEEL BARS

Table 8

(Reprinted with permission from Joseph T. Ryerson & Son, Inc.)

Size	*Square*	*Round*
1/4″	.2 lbs. per ft.	.15 lbs. per ft.
5/16″	.32 " " "	.25 " " "
3/8″	.47 " " "	.36 " " "
7/16″	.64 " " "	.50 " " "
1/2″	.84 " " "	.65 " " "
5/8″	1.31 " " "	1.03 " " "
3/4″	1.90 " " "	1.49 " " "
1″	3.3 " " "	2.6 " " "

LUBRICANTS FOR CUTTING TOOLS

Table 9

(By permission of Morse Twist Drill and Machine Company.)

Material	*Turning*	*Drilling*	*Reaming*	*Tapping*
Tool steel	lard oil	lard oil	lard oil	lard oil
Mild steel	dry	lard oil	lard oil	lard oil
Cast-iron	dry	dry	dry	dry
Brass	dry	dry	dry	dry
Copper				
Babbitt				
Glass		turpentine		

APPROXIMATE DRAFT OF PLOWS IN DIFFERENT SOILS PER SQUARE INCH OF CROSS-SECTION OF THE FURROW SLICE

(By permission of International Harvester Company.)

Table 10

Soil	*Resistance*
Sandy loam	2 to 3 lbs.
Wheat and corn stubble	3 to 5 lbs.
Clay soil	6 to 8 lbs.
Tame grass sod	8 to 15 lbs.
Gumbo	16 to 20 lbs.

For example, a fourteen-inch plow cutting a furrow slice six inches deep cuts eighty-four square inches, cross-section. In clay soil the resistance would be 84 × 8 lbs. = 672 lbs.; while in gumbo soil it would run as high as 1,680 pounds.

EXTINGUISHING A GASOLINE FIRE IN THE ABSENCE OF A GOOD MODERN FIRE EXTINGUISHER

Use flour, sand, or earth in the order named. Ammonia is very effective if the flame is confined to a small space.

LOG MEASURE

To ascertain the number of board-feet in a log of a given size, deduct four inches from the diameter at the small end. Square the remainder and multiply by the length of the log. Divide this product by 16.

If the log is more than twenty-four feet long, use the diameter at the center of the log.

HAY MEASUREMENT (WELL SETTLED)

Multiply the height of the stack at the middle of the end by the width in feet. Take two-thirds of the product and multiply it by the length of the stack. If it is wild hay, divide by 343; if tame hay, divide by 512. The result will be the number of tons or fraction thereof in the stack.

SHINGLING INFORMATION

One thousand shingles or four bunches will cover 100 square feet of roof when the shingles are laid four inches to the weather. Six pounds of nails are required for every 1,000 shingles laid.

UNITED STATES STANDARD BOLTS AND NUTS

TABLE 11

Screw size	*Threads per inch*	*Tap-drill size*	*Nut width across flats*	*Thickness of plain nut*
¼″	20	13⁄64″	½″	¼″
5⁄16″	18	¼″	19⁄32″	5⁄16″
⅜″	16	5⁄16″	11⁄16″	⅜″
7⁄16″	14	23⁄64″	25⁄32″	7⁄16″
½″	13	27⁄64″	⅞″	½″
9⁄16″	12	15⁄32″	31⁄32″	9⁄16″
⅝″	11	17⁄32″	1 1⁄16″	⅝″
¾″	10	41⁄64″	1¼″	¾″
⅞″	9	¾″	1 7⁄16″	⅞″
1″	8	55⁄64″	1⅝″	1″

FASTENINGS FOR WOOD AND METALS

The most commonly used fasteners for wood or metals are nails, screws, bolts, and rivets. Glue is also frequently used for repair or construction work in wood. A well-selected supply of the fasteners should be kept on hand in a convenient place so as to be readily available for use at any time. The following tables are included as helpful guides in choosing fasteners appropriate to the work to be done.

TABLE 12

Size, Length, Gauge, and Approximate Number Per Pound of Steel Wire Nails

Size	*Length in inches*	*Gauge*	*Number per pound*
2d	1	15	876
3d	1¼	14	568
4d	1½	12½	316
5d	1¾	12½	271
6d	2	11½	181
7d	2¼	11½	161
8d	2½	10¼	106
9d	2¾	10¼	96
10d	3	9	69
12d	3¼	9	63
16d	3½	8	49
20d	4	6	31
30d	4½	5	24
40d	5	4	18
50d	5½	3	14
60d	6	2	11

TABLE 13

Diameters of Wood-Screws

Number	*Diameter*
0	.058
1	.071
2	.084
3	.097
4	.110
5	.124
6	.137
7	.150
8	.163
9	.176
10	.189
11	.203
12	.216
13	.229
14	.242
15	.255
16	.268
17	.282
18	.295
19	.308
20	.321

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